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Life Cycle Assessment of Agricultural Production: Inventories and Impact of Land Use on Soil Degradation

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ABSTRACT

The global population is growing and requires increasing amounts of food. Agricultural production yields have increased substantially within the last century and are still rising, but despite this success, unintended damages to the environment can occur. These include soil degradation, polluted water bodies, reduced biodiversity and climate change impacts. To limit environmental impacts while meeting food demand of the future population, thorough planning of the future food system is inevitable. For this, quantitative tools to understand and assess environmental impacts are needed.

Life Cycle Assessment is a comprehensive tool used for the assessment of environmental impacts. Using this tool, environmental assessments of agricultural products and production systems have increased in number in recent years, reflecting the growing sense of importance. Along with the tool's increasing utilization, the method has been developed further to meet the specific requirements of the agricultural systems. This thesis aims to contribute to the advancement of Life Cycle Assessment for agricultural products and production systems by providing Life Cycle Inventories for agricultural products and by developing methodologies that allow for a comprehensive impact assessment.

In this thesis, first a literature review comparing Life Cycle Assessments of organically and conventionally produced products is completed (Chapter 2). From this literature review, recommendations for future studies that compare farming systems were derived. For example, system specific characteristics, such as nitrogen-fluxes, should be differentiated in Life Cycle Inventories to adequately reflect the different methods of crop production. In addition, Life Cycle Impact Assessment methods should encompass all relevant impact categories in order to avoid burden shifting and account for possible tradeoffs. Finally, the analysis requires a consistent set of Life Cycle Inventories covering a broad range of agricultural products.

A comprehensive and consistent dataset for fruit and vegetables, one important product group, was set up in Chapter 3. This dataset addressed the shortcomings mentioned above and considered detailed processes. The datasets were published as a paper and incorporated into ecoinvent, a well-established Life Cycle Inventory database, making them available to Life Cycle Assessment practitioners. Another technique to obtain large datasets was developed in Chapter 4. This chapter provides a toolkit to estimate the energy demand of food processing and, hence, covers an important aspect of food related Life Cycle Inventories.

The Life Cycle Inventories established in Chapters 3 and 4 were assessed in terms of environmental impacts. The results show that a large reduction of a food's carbon footprint is achievable by consuming seasonal and local fruits and vegetables. However, local products from fossil fuel heated greenhouses have a higher carbon footprint than products imported from longer distances, as long as transport was isolated to ship, train and/or truck, and not by airplane. The example of frozen spinach showed that a considerable share of the impact can arise from the processing stage, emphasizing the necessity to analyze entire production value chains.

While Chapters 3 and 4 focused on a small selection of impact categories, it was acknowledged in Chapter 2 that a broad coverage of impacts is needed to avoid unintended burden shifting and to provide reliable decision support. In order to supplement the variety of impact categories assessed in conventional Life Cycle Assessment and fill the important gap of soil degradation impacts, Chapter 5 presents a framework that includes impacts of land use on soil quality. This framework globally assesses the impact on the Biotic Production Potential caused by the different agricultural production systems. Various soil degradation impacts are quantified in terms of "long-term yield losses" that are afterwards combined into an overall impact on the Biotic Production Potential.

One particular impact pathway is operationalized in Chapter 6. A statistical-empirical model is used to assess long-term yield losses of soil compaction. A database providing relevant production data for 81 arable crops and their corresponding production systems is compiled and used to model elementary flows that are a proxy for the pressure on soil. Global Characterization Factors were based on an empirical model, indicating yield losses per elementary flow. As an input to this model, global coverage of soil moisture clay data at a spatial resolution of 1x1 km was made available. The soil moisture data are modeled by using global soil water content and available water capacity data. Global maps of the soil texture data, available from the Institute for World Soil Information at a 250x250m resolution, are used to calculate soil clay maps adequate to calculate environmental impacts. Compaction impact results for different mechanized crop growing systems were quantified. Depending on crop and production location, production losses amounted to between 0% and 50% of the yield, when cumulating all long-term losses over the next 100 years as referred to the current yield. This is a relevant fraction and demonstrates that soil compaction impacts should be included in the analysis of future food systems, especially when it comes to shifts in production areas for certain crops either due to the need for expanding growing areas or changing climatic conditions. In terms of mitigation, the influence of the crop choice showed to be higher than the influence of the chosen production system. The spatial variations of soil moisture and clay content are reflected in the results and show hotspot regions that are especially susceptible to compaction impacts.

While the parts of the thesis related to Life Cycle Inventory are readily applicable in further studies and in practical Life Cycle Assessments, the parts related to quantification of the impact assessment need additional research in order to fully reach operability. The recommendations developed in this thesis provide a solid basis for future research that allows for a more comprehensive assessment of impacts due to food production.

ZUSAMMENFASSUNG

Die wachsende Bevölkerung auf der Erde benötigt zunehmend mehr Nahrungsmittel für eine ausreichende und gesunde Ernährung. Die Erträge aus der Landwirtschaft sind in den letzten Jahrzehnten stetig gestiegen. Die Zunahme erfolgte jedoch auf Kosten der Umwelt. Bodendegradation, Wasserverschmutzung oder Biodiversitätsverluste sind einige Folgen davon. Um die Fehler der Vergangenheit zu vermeiden, braucht es Methoden, um die geplanten Anbaustrategien bezüglich ihrer Umweltauswirkung und bezüglich der erwarteten Erträge zu überprüfen.

Die Methode der Ökobilanzierung eignet sich für die Analyse von einzelnen Produkten oder ganzen Agrarsystemen, da sie die Umweltwirkung der Aktivitäten umfassend abbilden kann. Die Anzahl Ökobilanzstudien, welche im Bereich der Nahrungsmittelproduktion gemacht werden, nimmt stetig zu und ist von zunehmender Bedeutung. Gleichzeitig hat sich die Methodik entwickelt, so dass sie die spezifischen Charakteristiken der Agrarsysteme immer besser berücksichtigen kann. Diese Dissertation möchte zu dieser Entwicklung beitragen, indem Sachbilanzen entwickelt und bereitgestellt werden und die verfügbaren Methoden zur Wirkungsabschätzung erweitert werden, um eine umfassende Beurteilung zu ermöglichen.

In einem Literaturüberblick wurden in Kapitel 2 34 Ökobilanzstudien verglichen, welche zum Ziel hatten, die Umweltwirkung von biologisch und konventionell angebauten Produkten zu vergleichen. Aus dieser Analyse konnten Empfehlungen für künftige Studien abgeleitet werden. Systemspezifische Charakteristiken, wie zum Beispiel die Nährstoffflüsse der verschiedenen Anbaumethoden, welche sich unterscheiden, müssen in den Inventaren differenziert werden. Deshalb braucht es umfassende und konsistente Inventare. Um eine Verschiebung der Umweltbelastungen zu vermeiden oder um die Umweltbelastung im Falle von sich widersprechenden Belastungen richtig zu beurteilen, ist eine Wirkungsabschätzung von allen relevanten Umweltwirkungen unabdingbar.

In dieser Dissertation wurden, um die oben erwähnten Lücken zu schliessen, zahlreiche umfassende und konsistente Sachbilanzen für die Produktion von Früchten und Gemüsen entwickelt und bereitgestellt. Sie wurden einerseits in einer Fachzeitschrift publiziert und andererseits in ecoinvent, einer der umfassendsten Sachbilanzdatenbanken, eingegeben, und so den Ökobilanz-PraktikerInnen zugänglich gemacht. Ein anderer Weg, Daten bereitzustellen, führte über die Entwicklung eines Toolkits, welches benutzt werden kann, um den Energieverbrauch von Verarbeitungsprozessen in der Lebensmittelindustrie zu berechnen. Die Verarbeitung ist neben dem landwirtschaftlichen Anbau ein weiterer bedeutender Teil, wo Umweltauswirkungen entstehen.

Die Umweltauswirkungen, welche durch die inventarisierten Produkte verursacht werden, wurden ausgewertet. Die Ergebnisse zeigen, dass ein grosser Teil des CO_2-Fussabdruckes vermieden werden kann, wenn Früchte und Gemüse saisonal und lokal konsumiert werden. Eine Ausnahme stellen Produkte dar, die in mit fossilen Brennstoffen beheizten Gewächshäusern produziert werden. Dann ist oftmals ein Import aus wärmeren Gegenden, wo die Gewächshäuser nicht beheizt werden, günstiger. Allerdings gilt das nur, wenn die Produkte per Bahn, Schiff oder Lastwagen transportiert werden. Es gilt nicht, wenn die

Produkte per Flugzeug transportiert werden. Am Beispiel des Tiefkühlspinates konnte gezeigt werden, dass nicht nur der landwirtschaftliche Anbau, sondern auch die Verarbeitung einen relevanten Anteil der Umweltauswirkungen verursacht. Es ist deshalb wichtig, dass die ganze Produktionskette in der Analyse mitberücksichtigt wird.

Die aufgestellten Sachbilanzen wurden auf zwei Wirkungskategorien hin beurteilt. Dies ist aber, wie zu Beginn der Dissertation dargelegt, zu wenig, um umfassende Auswertungen zu machen. Insbesondere für Agrarsysteme ist es wichtig, auch die Bodennutzung und ihre Auswirkungen auf die Bodenqualität beurteilen zu können. Es wird deshalb in dieser Dissertation ein Konzept erarbeitet, welches eine Wirkungsabschätzung der Bodennutzung auf die Bodenqualität erlaubt. Die Methode soll global anwendbar sein, alle relevanten Wirkungspfade bezüglich Bodendegradation beinhalten und die Beurteilung von Produkten aus verschiedenen Anbaumethoden erlauben. Die Wirkungsabschätzung erfasst die Langzeitertragsverluste durch Bodennutzung und aggregiert diese anschliessend hinsichtlich der Auswirkung auf das biotische Produktionspotentials eines Bodens.

Die Umsetzung dieses Konzeptes erfolgte entlang eines Wirkungspfades. Der Langzeitertragsverlust, welcher bei einer Bodenverdichtung entsteht, wurde quantitativ abgeschätzt. Dafür wurden Daten für die Produktion von 81 Ackerfrüchten in verschiedenen Produktionsweisen erfasst. Die Spezifikationen der angewendeten landwirtschaftlichen Maschinen wurden in einem zweiten Datensatz zusammengestellt. Mithilfe eines empirischen Modelles konnten so Elementarflüsse modelliert werden, welche als Annäherung für den Druck auf den Boden angenommen werden. Globale Charakterisierungfaktoren wurden mit dem zweiten Teil des Modells berechnet. Die beiden Input-Datensätze widerspiegeln die Bodenfeuchtigkeit und den Lehmgehalt, welches beide relevante Faktoren bei der Entstehung der Bodenverdichtung sind. Für die Berechnung der Bodenfeuchtekarten wurden globale Karten über den Bodenwassergehalt und nutzbare Feldkapazität verwendet. Die Karten für die Lehmgehalte der Böden in der Auflösung von 250x250m wurden den Texturdaten von ISRIC (Institute for World Soil Information) entnommen und verarbeitet. Durch die Kombination von Elementarfluss und den Charakterisierungsfaktor, welcher den Ertragsverlust pro Elementarfluss beinhält, können so die Ertragsverluste, welche durch Bodenverdichtung entstehen, berechnet werden. Je nach Anbaugebiet und Ackerfrucht entstehen Verluste von 0-50% einer momentanen Ernte, welche über 100 Jahre verteilt auftreten. Dies ist ein relevanter Anteil und es zeigt, dass die entstehenden Verluste durch Bodenverdichtung in die Wirkungsabschätzung für zukünftige Anbausysteme miteinbezogen werden müssen. Dies gilt insbesondere dann, wenn sich die Anbaugebiete einer bestimmten Ackerfrucht verschieben, sei es aufgrund zusätzlich benötigter Anbauflächen oder aufgrund veränderter klimatischer Bedingungen. In mechanisierten Anbausystemen ist es wirkungsvoller, die gewählte Ackerfrucht anstatt die Anbaumethode zu ändern, um die Verluste durch Bodenverdichtung zu verringern. Es gibt Anbaugebiete, welche ein besonders hohes Risiko für eine Verdichtung aufweisen und durch hohe Bodenfeuchte- und Lehmgehalte in ihren Böden wiederzuerkennen sind.

Die Ergebnisse aus dem ersten Teil der Dissertation, die Sachbilanzen, sind sowohl in der Wissenschaft, wie auch in der Praxis in vollem Gebrauch. Währenddessen braucht der zweite Teil, die Umsetzung der Methodenerweiterung in der Wirkungsabschätzung, noch mehr

Forschungsbemühung, um operationell einsetzbar zu werden. Langfristig kann aber eine umfassende Methode zur Abschätzung der Auswirkungen auf Bodendegradation entstehen, wenn die in dieser Dissertation gemachten Empfehlungen umgesetzt werden.

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CHAPTER 1

INTRODUCTION

"As I said often, we don't have plan B because there is no planet B." (Ban 2016)

1.1 AGRICULTURAL PRODUCTION

Traditional agriculture, where inputs required for farming were generated on-site, started to change in the early years of the last century (Jain 2010). Since the beginning of the 1960s the change is referred to as the "Green Revolution", a period of time that was marked by the development of high-yielding varieties of wheat, rice and maize. The breeding of such varieties was possible due to the establishment of international cooperating research institutes lead by the Consultative Group on International Agricultural Research (CGIAR). The investments in production technology, such as fertilizing and pest control (chemical fertilizer and agro-chemicals) and irrigation were necessary to create the optimal conditions for the high-yielding breeds to thrive. Positive impacts on poverty reduction were possible and the conversion of thousands of hectares into arable land was avoided (Stevenson, Villoria et al. 2013), even if the success was not evenly distributed over the globe. The poverty reduction was relatively lower in the marginal production environments (Pingali 2012). The volume of the worldwide agricultural production has doubled and the trade has increased threefold within 30 years (FAO 1996).

Despite its success the Green Revolution leaves behind unintended environmental and social consequences (Pingali 2012), that, at least in part, diminish the value of success. The ratio of energy output to energy input has decreased. The application of the technology enhanced soil degradation, polluted water resources, etc. (Kendall and Pimentel 1994). This, in turn, caused deforestation for gaining further arable land. The dependency of the farmers on high-yield breeds curtailed the farmer's privilege and often caused financial problems to smallholders.

The criticism of a production model that relies on a few staples and on fossil energy started in Rio in 1992. At the same time, the investments in agriculture dropped. Only when it came to the 2008 food price spikes – especially in countries where agricultural production was still fuelling the engine of growth and reducing hunger – the interest in agricultural investment renewed (Pingali 2012). Calls for Green Revolution 2.0, that must address the successes and failures of the first Green Revolution, became louder. However, the challenges have grown with the growing population.

According to the UN Department of Economic and Social Affairs, the world population is expected to reach 9.8 billion inhabitants in 2050. This is roughly 83 million people being added every year despite declining fertility levels. This information is essential to know when guiding the world towards achieving the Sustainable Development Goals (UN Department of Economic and Social Affairs 2017).

The Millennium Development Goals (MDG), a universal framework for the development of the nations, set up by the United Nations, entered into force in the year 2000 with 8 goals. Goal one was the eradication of hunger and goal eight to ensure environmental sustainability. The latter contained, amongst other things, the goal to reduce the environmental effects of “resources and biodiversity loss” (United Nations 2007). The succeeding Sustainable Development Goals (SDG) in 2016 expanded to 17 global goals with 169 targets (UNDP 2016). Goal two, “Zero Hunger”, strives for ending hunger, achieving food security, improving nutrition and the promotion of sustainable agriculture. Targets of goal two are, amongst others, doubling the agricultural productivity by 2030 with sustainable food production systems and resilient agricultural practices that help to maintain ecosystems, overcoming environmental disasters and improving land and soil quality (United Nations 2016). Goal fifteen, “Life on Land”, reinforces the combat of desertification and the halt and reversal of land degradation (UNDP 2016). The significance is apparent when looking at the state of agricultural production.

1.2 ENVIRONMENTAL IMPACTS OF AGRICULTURAL PRODUCTION

Conway (2000) describes the cumulative effect of environmental degradation that affects yields and that are at least partly caused by agricultural production itself. All environmental compartments are affected. Soils are eroding, losing their fertility, and are contaminated due to excessive pesticide use. They are subjected to eutrophication and acidification. In many countries prime cropland is lost to construction sites (Sasson 2012). Water supplies are squandered; nitrate levels in drinking water are too high due to excessive fertilizer use. Rangelands are overgrazed and fisheries overexploited. Increased methane, carbon dioxide, and nitrous oxide emissions from intensive agriculture contribute to the global warming potential, which again harms agricultural production (Conway 2000).

New arable land is gained by clearing forests that can, for example, increase rainfall run-off and erosion (Sasson 2012). Habitat loss, disturbance and fragmentation of either natural ecosystems or farming systems represent threats to biodiversity, which is important for agriculture due to ecosystem services it provides. Farmers are key to manage their system and in the end all of our system. It is not surprising that different stakeholders are asking for a Green Revolution 2.0.

1.3 GREEN REVOLUTION 2.0: EXPECTATIONS ON FUTURE AGRICULTURAL PRODUCTION.

Intense debates about future agricultural production are going on. The expectation is to nourish future populations with healthy, socially and environmentally sustainable produced food. To achieve the goal, proposed pathways of those who take part in the debate, differ widely. The approaches can be categorized into three terms: Conventional Intensification, Sustainable Intensification and Ecological Intensification. Conventional Intensification is business-as-usual and uncontroversial, but considered not to be sustainable (Kuyper and Struik 2014). Taking into consideration that agriculture constitutes a large driver of planetary change (Steffen, Broadgate et al. 2015), it is at the same time most affected by these changes (Rockstrom, Williams et al. 2017). Rockstrom, Williams et al. (2017) argue that only a Sustainable Intensification of Agriculture (SIA) can deliver the productivity to meet rising food needs within planetary boundaries. Some of the proposed key operational strategies are: using natural capital and multi-functional ecosystems as tools to develop productive and resilient farming systems, utilize varieties and breeds with a high ratio of productivity, adopt circular approaches for natural resource use, assisting farmers in adoption of new farming techniques and enable robust institutions, especially led by woman. Already adopted SIA principles, e.g. in India's 12th Five Year Plan or in the strategic plan of the CGIAR, could launch the Green Revolution 2.0.

A more holistic approach to achieve food security and sustainability is the conversion to organic agriculture, which is one concrete production system (Nemecek, Dubois et al. 2011). Calculations about feasibility are recently published by Muller, Schader et al. (2017). The authors conclude that a global organic agriculture system can provide the 2050 population with sufficient food and reduce environmental impacts at the same time. However it presupposes a reduction of animal product consumption, which is free from food competing feed, and food wastage. Without implementing these two measures the conversion would lead to increased agricultural land use.

A similar approach is followed by Zimmermann, Nemececk et al. (2017). In their study about the future diet of Switzerland's population in an eco-friendly and resource-conserving manner they include production and consumption stages. The environmental impact of the consumption is evaluated using Life Cycle Assessment methods respecting dietary and production criteria (e.g. by distinguishing grassland and crop land). The assessed environmental impacts from the Swiss population's diet can be more than halved, if it is possible to change the diet: the most prominent changes are a sharp reduction of meat, alcohol and edible oil consumption. To produce the milk for unprocessed dairy products, the cattle feed would need to be harvested from domestic grasslands. Avoiding food losses, especially at the consumption stage, add to the significant reduction in environmental impacts. The analysis shows a great improvement potential for the protection of the environment but at the same time also for meeting the dietary recommendations and therefore the health of a population. Additionally, the analysis shows a potential for an improvement of the degree of self-sufficiency.

1.4 LIFE CYCLE ASSESSMENT

Life Cycle Assessment (LCA) has become an important decision support tool to quantitatively compare and optimize the environmental performance of products and services. It models environmental cause-effect relationships. The assessment preferably encompasses whole life cycles (from cradle to grave) in order to avoid burden shifting. This has grown in importance with the broadening of the global supply chains. Life Cycle Assessment underlies a four steps procedure that embraces goal and scope definition, Life Cycle Inventory (LCI), Life Cycle Impact Assessment (LCIA) and the interpretation of the LCI and the LCIA results (ISO 2006).

1.4.1 LIFE CYCLE INVENTORIES OF AGRICULTURAL PRODUCTS

One of the most prominent challenges in assembling LCIs of agricultural products is the variety of producers. One third of the world's population obtains its livelihood from the first sector (Beck, Haerlin et al. 2016). This means there are a lot of different producers and therefore production methods (Notarnicola, Sala et al. 2017). If the goal of a study is the environmental optimization of a production site or a farm, LCA practitioners are often working together with the customers of the study and are then able to collect primary data on the farm. This data become available to the scientific communities because the studies are sometimes published, as in the cases of the environmental assessment of cocoa and chocolate made in Italy (Recanati, Marveggio et al. 2018), of oil palm cultivation in Thailand (Silalertruksa, Gheewala et al. 2017), mustard oil cultivation in India (Khatri, Jain et al. 2017), peanut butter production in the U.S. (McCarty, Sandefur et al. 2014), production of Iranian peaches (Nikkhah, Royan et al. 2017) and cherry tomato production under Mediterranean conditions (Romero-Gamez, Anton et al. 2017). The number of studies published on Life Cycle Assessment of food and beverages has increased exponentially in the last years (Ponsioen and van der Werf 2017), but they are very heterogeneous and lack complete coverage of crops, production systems and geographical scope.

Different attempts have been made to set up guidelines for a harmonization of the LCIs in order to guarantee a certain comparability of assessment results. The latest general guidelines were published by the World Food LCA Database (WFLDB) project (Nemecek T., Bengoa X. et al. 2015). The current version (v3.0) aims to serve as an open reference for LCA practitioners and LCI database developers, compliant with the ISO standards. At the same time the publishers and their consortium established 400 datasets for crops, animal products and food products in 40 countries and submitted them to the Ecoinvent Centre for publication in 2016 and 2017 (Ecoinvent 2017). The second phase of the WFLDB project, which started in 2016, further worked on improving datasets and expanding the guidelines in cooperation with all stakeholders. Thereby the latest methodological developments and global consensus on key topics such as pesticides emissions modelling, land use change or carbon sequestration in grassland were considered (Bengoa, Lansche et al. 2016). A few of these datasets replaced the datasets submitted to the Ecoinvent database by the early work done in this thesis.

The project "Life Cycle Assessment of Basic Food" (2000 to 2003) resulted in an "LCA Food data base" which was last updated in 2007 and is no longer available today (Nielsen, Nielsen et al. 2003). The United States Department of Agriculture (USDA) National Agricultural Library (NAL) hosts an LCI data module in order to collect, curate, archive, publish, and preserve LCA data sets related to agriculture, in a consistent documentation standard. It is an open LCA dataset and is updated and maintained to date (United States Department of Agriculture 2017). The USLCI open data also contains datasets on agricultural production. However, this dataset has to be examined before use because it contains processes without supply chain inventories (PRe´Consultants 2017).

The Blonk Consultants, a sustainability consulting firm in the Netherlands, provide and maintain the Agri-footprint database. It contains around 3500 products and processes related to agricultural production. The first version was released to public in 2014. The second version (autumn 2015) is by default available in the commercial LCA software SimaPro (PRe´Consultants 2017), as is Ecoinvent as well. It is reviewed by Dutch National Institute for Public Health and the Environment (Blonk Consultants 2015).

Aside from the Ecoinvent and Agri-footprint database, Agribalyse® is a third commonly used database for agricultural LCIs. The objective of Agribalyse® was to develop homogenous LCIs for French agricultural products and a few products imported to France. It contains more than 200 datasets at farm gate (ADEME 2017). The initiative was taken to support labelling policies in order to improve the environmental performance of the French agricultural sector and the consumption (Colomb, Ait et al. 2015). Background processes (non-agricultural) used in Agribalyse® were taken from Ecoinvent (Agribalyse® Consortium 2016). A new phase for Agribalyse® (2014-2018) will enlarge the dataset, improve the methodology and the calculation tools (ADEME 2017).

Several private consulting companies also collect LCI data, for example, ESU services Ltd., Schaffhausen, Switzerland or thinkstep, Leinfelden Germany.

Compiling LCI data that includes all raw materials, energy and waste flows of a product during its entire life cycle is time consuming. Specific primary data are often not made available. Secondary datasets, sourced from a third-party Life Cycle Inventory database, as mentioned above, or from publications and reports are often used instead (Miah, Griffiths et al. 2017). Corrado, Castellani et al. (2018) assessed twelve datasets for crop production in France using Agri-footprint, Agribalyse and Ecoinvent. Different aspects like system boundaries, agricultural operations, application and fate of fertilizers and pesticides, irrigation assumptions, etc. and its impacts were compared. The differences led to different LCIA results. The conclusion was that a chosen dataset has to thoroughly be matched with the goal and scope of a study (Corrado, Castellani et al. 2018).

Big datasets and guidelines for the compilation of agricultural LCIs as described above need practical fundamentals to be established. For the comparison of the environmental performance of different products, it is important to establish databases that are set up in a consistent and comprehensive way. For the assessment of the environmental performance of a system that goes beyond the comparison of a few products it is necessary to have big datasets in this way. No comprehensive and consistent dataset was available for the Life Cycle Assessment of fruits and vegetables. Fruits, vegetables and other agricultural products are often processed in industry and sold as processed or semi-processed food items to consumers. In order to follow the whole value chains of products within an LCA, the production and additionally the processing datasets are needed.

1.4.2 LIFE CYCLE IMPACT ASSESSMENT METHODS FOR AGRICULTURAL PRODUCTS

Life Cycle Inventories, i.e. the emissions and resources going into producing a product, are assessed regarding potential environmental impacts. This third stage in an LCA is referred to as

Life Cycle Impact Assessment (LCIA). With the increasing environmental pressure caused by agricultural production and the global trade of agricultural products it is important to assess all relevant environmental damages in order to avoid burden shifting between the various impacts. Around 99% of the global food production (in calories) is from land-based production (Jones, Panagos et al. 2012), causing environmental impacts that are particularly pertinent to soil.

The damages of land and water use are site specific and require a regionalized LCIA, designated as local or regional impacts (UNEP Setac Life Cycle Initiative 2016), whereas damages such as climate change have global impacts. The UNEP-SETAC Life Cycle Initiative has recommended methods for the impact categories of climate change, water-consumption impacts and land-use impacts on biodiversity (UNEP Setac Life Cycle Initiative 2016), as well as human toxicity and ecotoxicity (Fantke, Bijster et al. 2017). Ecotoxicity, eutrophication, acidification and land use biodiversity impacts are important regional impact categories for agricultural production affecting a (sub-)continent or a smaller region around the point of emission (Rosenbaum, Hauschild et al. 2018). They have been incorporated into standard LCIA methods. Methods to assess water use in agricultural production are also available (Pfister, Koehler et al. 2009, Boulay, Bulle et al. 2011, Motoshita, Itsubo et al. 2011, Pfister, Saner et al. 2011, Hoekstra, Mekonnen et al. 2012, Berger, van der Ent et al. 2014, UNEP Setac Life Cycle Initiative 2016) and are implemented e.g. in SimaPro, a standard LCA software. The Ecological Scarcity 2013 method (Frischknecht and Büsser Knöpfel 2013) calculates an environmental pressure on soil directly by considering pesticides and heavy metals emitted to soil and indirectly via environmental pressures on air and water quality. The characterisation factors quantify the relative impact of substances to a target value.

While methods to assess impacts to terrestrial ecosystems from land use, water use, acidifying emissions and toxic emissions are readily available and operational (Pfister, Koehler et al. 2009, Chaudhary, Verones et al. 2015, UNEP Setac Life Cycle Initiative 2016, Fantke, Bijster et al. 2017), only a few initial approaches exist for assessing soil quality and productivity as a resource (Garrigues, Corson et al. 2012, Vidal Legaz, Maia De Souza et al. 2017).

Methods addressing overall soil quality: SALCA-SQ (Oberholzer, Knuchel et al. 2012) is a method that uses nine indicators such as e.g. soil organic matter (SOM), macro pore volume and microbial activity to address soil quality. It is the method with the highest level of description of soil quality and with a high data requirement. Impacts of management measures are assigned to impact categories and then the influence of these impact categories on the soil properties are determined (Roesch, Gaillard et al. 2017). The method is calibrated for Swiss farms. In another method, impacts on soil quality are reduced to the function of soil fertility indicated by biodiversity and free net primary biomass (Lindeijer 2000). Achten, Mathijs et al. (2009) suggest "ecosystem structural and functional quality" as endpoint indicators with soil fertility (cation exchange capacity, base saturation and SOM) and soil structure (infiltration rate) as midpoint indicators. Milà i Canals, Romanyà et al. (2007) propose soil organic matter as a proxy and sole indicator of soil quality. A refined version of the model uses the change in soil organic carbon as an indicator for impacts on the Biotic Production Potential (BPP), which is an important endpoint for the Area of Protection (AoP) "Natural Resources" (Brandao and Canals 2013). Cowell and Clift (2000) suggest that the levels of SOM as well as changes in soil mass,

mass of nutrients, weeds and weed seeds, pathogens, salts, the soil pH and the texture and structure of the soil are necessary to measure soil quality. Other attempts to assess soil quality have been made with exergy-based accounting methods (Alvarenga, Dewulf et al. 2013, Alvarenga, Erb et al. 2015).

Methods addressing soil functions: Soil functions are explicitly addressed in LANCA®, another multi-indicator model that calculates indicators for erosion resistance, mechanical filtration, physicochemical filtration, groundwater replenishment, and biotic production (Beck, Bos et al. 2010, Bos, Horn et al. 2016). The functional method of Baitz (2002), the basis for LANCA®, was also used by Saad, Margni et al. (2011) to develop spatially differentiated Characterization Factors (CF) assessing erosion regulation, freshwater regulation and water purification for Canadas ecoregions. The results were extrapolated to a global scale level for seven land use types (Saad, Koellner et al. 2013).

Methods addressing single soil degradation processes: A method assessing effects of soil erosion on soil resource stock and ecosystems net primary production is presented with globally applicable and spatially differentiated CFs. The results of the adhered case study emphasize on the importance of a regionalized assessment (Núñez, Antón et al. 2012). A more recent development is the spatially explicit CFs for soil erosion, as a function of crop and management practice on a global scale and expressed in kg soil lost per kg of product (van Zelm, van der Velde et al. 2017). Desertification is addressed in a method based on four biophysical variables: aridity, erosion, aquifer overexploitation and fire risk (Núñez, Civit et al. 2010). An impact model for the assessment of potential land degradation due to soil salinization is proposed by Feitz and Lundie (2002). It is based on the relationship between the sodium adsorption ratio and the electrolyte concentration and limited to soil salinization from irrigation practices. The model can be adapted to specific sites by the use of electrolyte threshold curves. Another salinity impact assessment that addresses the total salinity potential for different compartments (atmosphere, surface water, natural surfaces and agricultural surfaces), is valid for South African conditions (Leske and Buckley 2003). Payen, Basset-Mens et al. (2016) review the existing approaches and provide the scientific basis to build a complete model assessing salinization impacts. A model developed by Garrigues, Corson et al. (2013) focuses on site-specific soil compaction due to machinery use. It requires detailed input information, but provides CFs for France, Brazil and Pakistan.

The systematic evaluation of the models by Vidal Legaz, Maia De Souza et al. (2017) showed that currently no model for assessing soil quality meets the necessary features, such as global availability of CFs, impeding the use in standard LCA studies. In their recent book chapter Dijkman, Basset-Mens et al. (2018) also conclude that, despite many achievements, a number of challenges, e.g. the completion of the LCIA methods with impact categories on soil quality, remain. Operational soil quality impact assessment indicators of land use with global coverage and the capability to distinguish between different agricultural systems are needed.

1.5 RESEARCH OBJECTIVES OF THE THESIS

The overall goal of the thesis is to advance Life Cycle Inventories for agricultural products and to develop methodologies, which allow for an assessment of the environmental impacts from agricultural production to the soil system, as it is described in Chapter 1.4.

In order to close the gaps, the following objectives are pursued:

(i) Literature review of LCA studies of agricultural production, with focus on different agricultural production systems (organic and conventional products).

(ii) Provision of consistent and comprehensive inventory data for the production of 34 fruits and vegetables, representing an important crop group of agricultural production.

(iii) Implementation of a toolkit for the calculation of LCIs of industrially processed food items.

(iv) Analysis of the LCA results (global warming potential and water stress index as representatives of two relevant impact categories for agricultural production) obtained by the impact assessment of the above mentioned inventories.

(v) Development of a framework for a Life Cycle Impact Assessment method that combines the relevant impact pathways for the environmental impact on soil quality.

(vi) Implementation of one of the impact pathways presented in the framework above and provision of CFs for the impact of soil compaction with global coverage and for different production systems.

1.6 STRUCTURE OF THE THESIS

The fulfilment of the discussed goals is structured as described in this chapter and graphically depicted in Figure 1.1. It encompasses five peer-reviewed and published articles. Each of the Chapters 2-6 corresponds to one article and the status of the article is indicated at the beginning of each chapter.

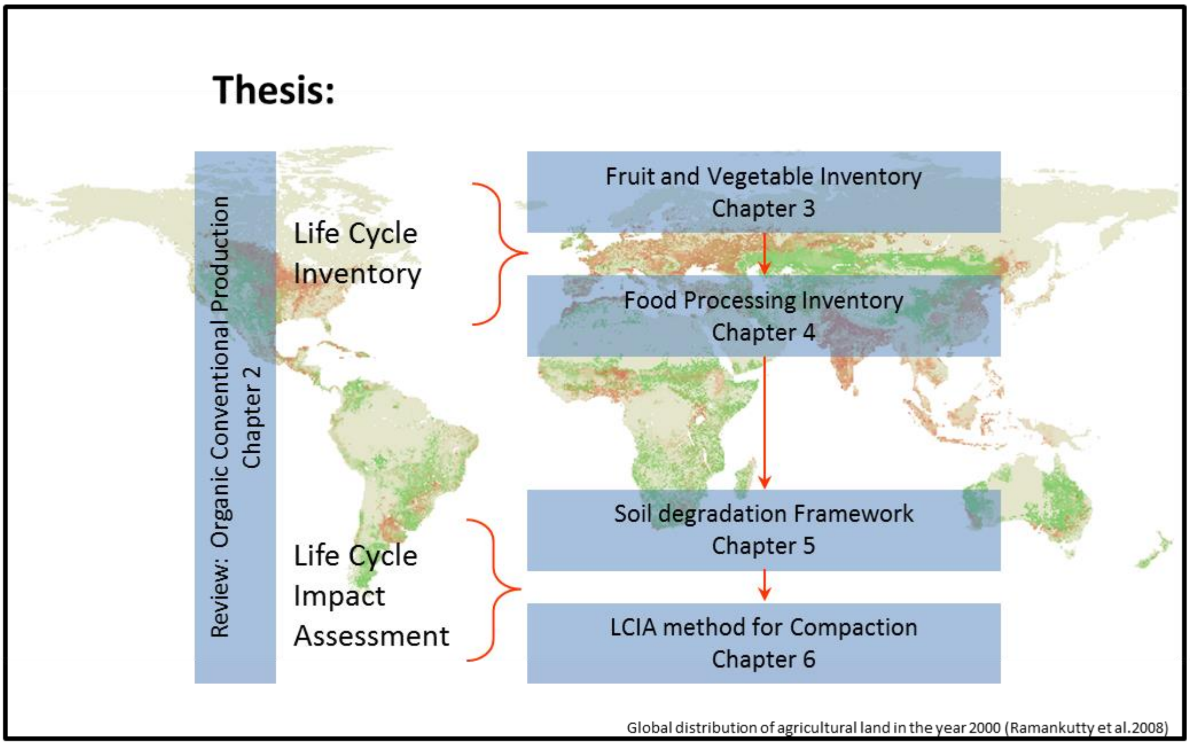

Figure 0.1 Structure of the thesis. The focus of the thesis is a) the enlargment of data basis in LCI and b) the advancement of the LCIA methods for a comprehensive assessment of the environmental impacts that are relevant in the analysis of agricultural products.

Chapter 1 introduces to the topic and outlines the objectives of the thesis, which are addressed in the following chapters.

With the increasing number of available LCAs on agricultural products and the evaluation of high-yielding and environmentally sound production systems, the requirement for a more differentiated assessment arises. The bases for such an improvement are explored in **Chapter 2**. 34 comparative LCA studies of organic and conventional agricultural products are reviewed and assessed concerning the system specific inventory analysis and the impact assessment modelling.

Chapter 3 presents inventory data of the most relevant 34 fruits and vegetables consumed in Switzerland. The LCI includes, among others, seedling production, farm machinery use, fuels for the heating of greenhouses, irrigation, fertilizers, pesticides, storage and transport to and within Switzerland. The datasets are analysed using LCIA methods for global warming potential and for water stress index. The results are applied to the amount of one year's fruit and vegetable sourcing of one Swiss retailer in order to improve the supply chain management.

Chapter 4 complements the LCI of Chapter 3 with a toolkit providing processing data. Estimation tools for the energy demand of food process unit operations, such as dehydration, pasteurization, freeze-drying or evaporation are provided. These operations can be combined according to the recipe to quantify the heat and electricity demand for processing operations. In combination with the inventory data on the production in Chapter 3 the LCIA can be performed for a large variety of processed food. The application is exemplified in a case study on frozen spinach.

One of the reasons for the somewhat limited validity of agricultural LCA studies, is the incomplete coverage of impact categories (Chapters 2 and 3). **Chapter 5** therefore proposes a new framework for the impact assessment of soil degradation in order to close a gap in impact assessment methods. The framework proposed encompasses four aspects on soil degradation developed to avoid overlapping.

Chapter 6 implements one of the described pathways in Chapter 5. It uses a statistical-empirical model to assess long-term yield losses through soil compaction in agricultural production. The model is applicable for different production methods and is able to calculate CFs on a global or regional level. A dataset for 81 crops and corresponding production system and specifications for 96 agricultural machineries are provided. Global soil texture and soil moisture datasets on a spatial resolution of one km are provided too.

Chapter 7 provides a synthesis of the thesis, as well as conclusions regarding the scientific and practical relevance and a critical appraisal of the work.

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CHAPTER 2

ENVIRONMENTAL IMPACTS OF ORGANIC AND CONVENTIONAL AGRICULTURAL PRODUCTS – ARE THE DIFFERENCES CAPTURED BY LIFE CYCLE ASSESSMENT

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Highlights

- We revealed considerable bias in comparative LCA studies on agricultural products.
- We suggest how to improve sustainability assessment of agricultural products in LCA.
- A more precise differentiation of farming systems is needed within LCA.
- In inventories we found large deviations between modeled and actual N-fluxes.

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The individual contribution of Franziska Stoessel consisted of collecting and preparing part of the data and their analyses and reviewing the manuscript for publication.

ABSTRACT

Comprehensive assessment tools are needed that reliably describe environmental impacts of different agricultural systems in order to develop sustainable high yielding agricultural production systems with minimal impacts on the environment. Today, Life Cycle Assessment (LCA) is increasingly used to assess and compare the environmental sustainability of agricultural products from conventional and organic agriculture. However, LCA studies comparing agricultural products from conventional and organic farming systems report a wide variation in the resource efficiency of products from these systems. The studies show that impacts per area farmed land are usually less in organic systems, but related to the quantity produced impacts are often higher. We reviewed 34 comparative LCA studies of organic and conventional agricultural products to analyze whether this result is solely due to the usually lower yields in organic systems or also due to inaccurate modeling within LCA. Comparative LCAs on agricultural products from organic and conventional farming systems often do not adequately differentiate the specific characteristics of the respective farming system in the goal and scope definition and in the inventory analysis. Further, often only a limited number of impact categories are assessed within the impact assessment not allowing for a comprehensive environmental assessment. The most critical points we identified relate to the nitrogen (N) fluxes influencing acidification, eutrophication, and global warming potential, and biodiversity. Usually, N-emissions in LCA inventories of agricultural products are based on model calculations. Modeled N-emissions often do not correspond with the actual amount of N left in the system that may result in potential emissions. Reasons for this may be that N-models are not well adapted to the mode of action of organic fertilizers and that N-emission models often are built on assumptions from conventional agriculture leading to even greater deviances for organic systems between the amount of N calculated by emission models and the actual amount of N available for emissions. Improvements are needed regarding a more precise differentiation between farming systems and regarding the development of N-emission models that better represent actual N-fluxes within different systems. We recommend adjusting N- and C-emissions during farmyard manure management and farmyard manure fertilization in plant production to the feed ration provided in the animal production of the respective farming system leading to different N- and C-compositions within the excrement. In the future, more representative background data on organic farming systems (e.g. N-content of farmyard manure) should be generated and compiled so as to be available for use within LCA inventories. Finally, we recommend conducting consequential LCA – if possible – when using LCA for policy-making or strategic environmental planning to account for different functions of the analyzed farming systems.

2.1 INTRODUCTION

Agriculture's impacts on the environment are substantial (Foley et al., 2005; Foley et al., 2011). In particular modern agriculture is accelerating the rate of biodiversity loss and is one of the major drivers of climate change and human induced changes to the nitrogen cycle, with these three processes having already exceeded the Earth's boundaries (Rockström et al., 2009). In order to become more sustainable farming systems should be developed and applied that minimize externalities by optimizing the use of internal production inputs (e.g. of farmyard manure) (Nemecek et al., 2011b) and/or implement ecological intensification, which involves replacing external inputs with ecosystem services (e.g. by enhancing natural biocontrol) while maintaining or even increasing yield levels (Bommarco et al., 2013).

Organic farming is often proposed as solution to reduce agriculture's impacts on the environment (Seufert et al., 2012b). However, yields in organic agriculture are usually lower than in conventional agriculture. For example, crop yield differences between organic and conventional systems range – while strongly depending on system and site characteristics – from 5 to 34% (de Ponti et al., 2012; Seufert et al., 2012a). So, more land is usually required to produce the same amount of food in organic farming systems than in conventional farming. Thus, the environmental benefits per product unit of organic farming might be outweighed; as was argued in the recent meta-analysis by Tuomisto et al. (2012).

In order to develop more sustainable farming systems, researchers and decision-makers need information about the strengths and weaknesses of different farming systems with respect to productivity and environmental impacts within the ecosystems' carrying capacity. Therefore, assessment tools are required that allow for comprehensive environmental impact assessments of different farming systems to enable informed conclusions.

Life Cycle Assessment (LCA) is increasingly used to assess the ecological sustainability of food products and is seen as a useful tool to evaluate environmental impacts of food products and production systems (Roy et al., 2009). LCA is the most comprehensive method available and useful for avoiding problem-shifting e.g., from one phase of the life cycle to another because it analyzes potential environmental impacts throughout a product's life cycle (ISO, 2006) including the supply chain and downstream processes (Finnveden et al., 2009). Results from LCAs may form the basis for making decisions for policy makers, producers as well as for consumers in selecting sustainable products and production processes (Roy et al., 2009).

A growing number of LCA studies has compared the environmental impacts of the same products produced in organic vs. conventional agriculture (see Table 2.1). Most of these LCA studies have found a lower environmental burden from organically produced products on a per area and year basis, but higher impacts have been found when evaluating emissions per product unit (e.g. Nemecek et al. (2011a) and the studies reviewed therein). Lower yields of organic farming systems leading to higher environmental impacts on a per product basis are seen as their main drawback (Tuomisto et al., 2012).

However, contemporary LCA studies report a wide variation in the resource efficiency of products from organic and conventional agriculture (e.g. studies on milk by (Cederberg and Mattsson, 2000; Thomassen et al., 2008b; van der Werf et al., 2009; Williams et al., 2006). Some of this variation may be explained by yield differences between organic and conventional agriculture, while some of the variation may depend more on farmer's management choices than on the farming system itself (Tuomisto et al., 2012). Alternatively, some of the variation reported by comparative LCAs of products from different farming systems may also be due to inaccurate modeling of characteristics specific to the farming systems related to the assessed products.

The objectives of this review are:

a) to determine the parameters leading to differences in environmental impacts between organic and conventional products within comparative LCAs; and

b) to analyze, whether these parameters reflected farming system specific differences adequately.

Further, we analyze whether comparative LCA studies on organic and conventional products can be used to draw general conclusions on the environmental performance of organic and conventional farming systems. Finally, the objective is to show how LCA can be improved to better differentiate between products from different farming systems.

2.2 METHODS

2.2.1 REVIEW OF PEER-REVIEWED COMPARATIVE LCA STUDIES AND LCA STUDY REPORTS

2.2.1.1 Literature search

We searched the ISI Web of Knowledge literature database (www.isiwebofknowledge.com) and the Scopus database (www.scopus.com) for LCA studies that compared organically and conventionally (i.e. non organic) produced commodities with no restriction on publication year or geographical context although review articles were excluded from the analysis. The search string "Life Cycle Assessment AND organic AND conventional" was used in combination with different keywords including milk, beef, pig, poultry, arable crops, fruits and vegetables. In peer reviewed journals and conference proceedings, we found 31 comparative LCA studies and studies using LCA methodology to assess only a single impact category (e.g. carbon footprint studies). Since we searched academic literature databases, this review includes only studies which primarily aimed at answering academic questions. However, such studies may serve as the scientific basis for decision making, such as on a regulatory level.

In addition we included three scientific reports, which were available on the internet, on comparative LCAs from the UK (Williams et al., 2006), Sweden (Cederberg and Flysjö, 2004), and Switzerland (Alig et al., 2012). These three reports were not peer reviewed although they are well known within the LCA community dealing with food and agriculture. The report from Sweden was the basis for the peer reviewed study by Flysjö et al. (2012) and the report from the UK was the basis for the peer reviewed study by Williams et al. (2010). Both peer reviewed studies were also included in this review. All of the 34 studies that were reviewed are listed in Table 2.1, which also indicates the commodities, the country, and the underlying data basis.

Further, we added inventories on organic and conventional products from ecoinvent v2.2 and from ESU-services Ltd. (Jungbluth et al., 2013) to the studies found in literature and included them in our analyses (see Section 2.2).

2.2.1.2 Evaluation criteria

The main focus of this review of LCA studies and inventories is on the question of how organic and conventional farming systems were differentiated and modeled within comparative LCAs in order to assess and compare environmental impacts of agricultural food products. The review was guided by the following evaluation criteria:

1. Goal and scope definition
    - What was the goal of the LCA?
    - Was the LCA conducted with an attributional or consequential perspective?
    - What allocation rules were applied?
    - What system boundaries were chosen?
    - What functional units were used?
2. Inventory
    - What was the data basis used (experimental data vs. modeled data)?
    - What assumptions were taken regarding farming practices (including yields)?
    - What emission calculation models were used?
    - Were site-specific emission and characterization factors applied?
3. Impact assessment
    - Which impact categories were assessed?
    - Which Life Cycle Impact Assessment (LCIA-) methods were used?
4. Interpretation of results
    - Were sensitivity analyses to choices of methods conducted?
    - Were uncertainty analyses of results conducted?
    - What conclusions were drawn?

2.2.1.3 Analysis of studies

The studies were grouped according to the commodities that were analyzed and each study was analyzed according to the evaluation criteria listed above (see Supplementary Material, Appendix A). If not explicitly reported in the studies, we calculated the environmental impacts per unit of area and year additionally to the impacts reported per unit of product. This way the cultivation intensity, and how impacts related to the different agricultural systems before dividing by the amount of yield, became transparent. In the studies of Kavargiris et al. (2009) Litskas et al. (2011), Michos et al. (2012) and Zafiriou et al. (2012) impacts were reported per area only. For these studies, we calculated impacts per product based on the yields reported in these studies. Furthermore, the productivity as the amount of product per area was calculated if it was not explicitly stated in a paper. The relative differences between the impacts and yields of organic and conventional farming systems were calculated for each study (see also Supplementary Material, Appendix A).

In some studies, organic farming practices were compared with several conventional systems of different intensities (Abeliotis et al., 2013; Alig et al., 2012; Casey and Holden, 2005;

Cederberg and Flysjö, 2004; Haas et al., 2001; Leinonen et al., 2012a; Leinonen et al., 2012b; Michos et al., 2012; Nemecek et al., 2011a; Villanueva-Rey et al., 2014; Warner et al., 2010; Williams et al., 2006; Zafiriou et al., 2012). To analyze how products from farming systems that differ substantially are assessed in LCA, we considered only the comparisons between organic agriculture with the highest intensity levels of conventional agriculture. A range of variants, including low-, upland, and alpine production systems in milk (Hörtenhuber et al., 2010) and suckler cow and feedlot systems in beef production (Alig et al., 2012) within organic and conventional agriculture were analyzed to identify differences between the environmental impacts of organic and conventional agriculture for each of the variants. No comparisons were carried out across variants. Some studies included transportation, storage, and/or processing after the farm gate (Alig et al., 2012; Gronroos et al., 2006; Liu et al., 2010; Meisterling et al., 2009). However, since the systemic differences between organic and conventional farming occur within agricultural production, we only considered the agricultural production phase in our analyses (cradle-to-farm gate). Further quantitative and qualitative data were extracted wherever possible such as to compare surplus nitrogen with the amount of nitrogen from the emissions' modeling.

2.2.2 ANALYSIS OF INVENTORY DATA

We supplemented the overview of published environmental impacts for organic and conventional products (Table 2.2) with inventory data from ESU-services Ltd. (Jungbluth et al., 2013) on milk, beef, pork, poultry, tomatoes, carrots, strawberries and pears; and ecoinvent inventories v2.2 on wheat, barley, soybean, and potatoes (Table 2.3): all of which are available for Swiss organic and integrated production (IP) (Nemecek and Kägi, 2007). IP production in this paper refers to the definition in Nemecek et al. (2011a) including principles such as equilibrated nutrient balance, ecological compensation areas, diversified crop rotation, soil protection during winter to reduce the risk of erosion and nitrate leaching, and targeted and restricted application of pesticides. For this overview, we considered only impacts reported per unit of product (Table 2.3). Ecoinvent inventories are widely used as background data in LCA studies so critical points on the inventory level regarding emissions' modeling are, therefore, potentially translated to any respective LCA study that uses these inventory data.

2.3 RESULTS AND DISCUSSION

2.3.1 OVERVIEW OF STUDIES REVIEWED

2.3.1.1 Scope of the studies

In total, 34 studies that used LCA methodology and which compared milk, beef, pork, poultry, eggs, fruits, vegetables, nuts, and arable crops from organic and conventional agriculture were reviewed (Table 2.1). Some studies compared more than one product (Alig et al., 2012; Bos et al., 2007; Gronroos et al., 2006; Nemecek et al., 2011a; Venkat, 2012; Williams et al., 2006; Williams et al., 2010). Milk was the product most often compared between organic and conventional agriculture (11 out of 34 studies reviewed), while six studies dealt with meat from different production systems, one study analyzed egg production and 19 studies compared various plant products. All but four studies (Cederberg and Flysjö, 2004; Flysjö et al., 2012; Williams et al., 2006; Williams et al., 2010) were fully independent and mostly used data from real farms to assess the environmental impacts of products from different production systems (Table 2.1). In Flysjö et al. (2012), the farm inventories from Cederberg and Flysjö (2004) were used for further analyses and Williams et al. (2010) built upon Williams et al. (2006).

Table 2.1 Comparative LCA studies reviewed.

Study	Products analyzed	Country	Data basis
Abeliotis et al. (2013)	Bean	Greece	Several producers involved in a labeling schemes (to derive average agricultural practice in the region under study)
Alig et al. (2012)	Beef, pig, poultry	Switzerland	Beef: 14 model farms based on data from 2534 conventional/1818 organic farms; Pig: 6 model farms based on data from 5397 conventional/258 organic farms Poultry: 3 production scenarios based on production data from one meat processing company
Basset-Mens and van der Werf (2005)	Pig	France	3 production scenarios based on French official farm statistical data and expert judgment, data from one local feed producer
Backer et al. (2009)	Leek	Belgium	1 organic/1 conventional agricultural research institute
Boggia et al. (2010)	Poultry	Italy	1 organic/1 conventional farm
Bos et al. (2007)	Potato, sugar beet, pea, leek, lettuce, beans	The Netherlands	Model farms for different farm types, data origin not further specified
Casey and Holden (2006)	Beef	Ireland	5 organic/5 conventional farms
Cederberg and Mattsson (2000)	Milk	Sweden	1 organic/1 conventional farm
Cederberg and Flysjö (2004)	Milk	Sweden	6 organic/9 conventional farms
Flysjö et al. (2012)	Milk	Sweden	6 organic/9 conventional farms
Gronroos et al. (2006)	Milk, rye	Finland	1 organic/1 conventional farm
Guerci et al. (2013)	Milk	Denmark	2 organic/3 conventional farms
Haas et al. (2001)	Milk	Germany	6 organic/6 conventional farms
Hörtenhuber et al. (2010)	Milk	Austria	Official Austrian farm statistical data (IACS database)
Juraske and Sanjuán (2011)	Orange	Spain	Typical production conditions from a Spanish orange production region
Kavargiris et al. (2009)	Grape	Greece	9 organic/9 conventional farms
Knudsen et al. (2010)	Soybean	China	20 organic/15 conventional farms
Kristensen et al. (2011)	Milk	Denmark	32 organic/35 conventional farms
Leinonen et al. (2012a)	Poultry	UK	Industry data/national inventories/database data
Leinonen et al. (2012b)	Eggs	UK	Industry data/national inventories/database data
Litskas et al. (2011)	Cherry	Greece	10 organic/10 conventional orchards
Liu et al. (2010)	Pear	China	3 organic/2 conventional farms
Meisterling et al. (2009)	Wheat	USA	Farm statistical data/literature data
Michos et al. (2012)	Peach	Greece	3 organic/4 conventional farms

Study	Products analyzed	Country	Data basis
Nemecek et al. (2011a)	2 crop rotations of arable crops	Switzerland	Long term field trials
Thomassen et al. (2008b)	Milk	Netherlands	11 organic/10 conventional farms
van der Werf et al. (2009)	Milk	France	6 organic/41 conventional farms
Venkat (2012)	Alfalafa, blueberry, apple, wine grape, raisin grape, strawberry, almond, walnut, broccoli, lettuce	USA (California)	Literature data (cost and return studies)
Vermeulen and van der Lans (2011)	Tomato	Netherlands	Statistical data from the greenhouse horticulture industry
Villanueva-Rey et al. (2014)	Wine grape	Spain	1 organic (biodynamic)/1 conventional vineyard
Warner et al. (2010)	Strawberry	UK	Total of 20 farms comprising 3 organic/6 conventional strawberry production systems
Williams et al. (2006)	Milk, beef, pig, poultry, wheat, oilseed rape, potato, tomato	UK	Farm statistical data (official UK and private company data), literature, expert judgment, existing inventories including ecoinvent
Williams et al. (2010)	Wheat, potato	UK	National survey data/literature data
Zafiriou et al. (2012)	Asparagus	Greece	3 organic/5 conventional farms

In the cases of milk, beef, pig, and egg production, all of the reviewed studies refer to middle or northern European agriculture (Table 2.1). In the case of poultry, one study was conducted in southern Europe in addition to two studies from middle and northern Europe. Of the studies on fruit, vegetables and arable crops, one study analyzed pear (Liu et al., 2010) and one soybean production systems in China (Knudsen et al., 2010). Further, two studies on different crops were conducted in the USA (Meisterling et al., 2009; Venkat, 2012). All of the other studies on fruits, vegetables, and arable crops were conducted in the context of European agriculture.

Almost all of the reviewed studies compared organic with conventional production systems to elicit which farming system is the most environmentally sustainable for the analyzed products. Seven studies furthermore aimed at identifying hot-spots of environmental impacts to enable deduction of mitigation options to reduce environmental impacts of farming systems (Alig et al., 2012; Basset-Mens and van der Werf, 2005; Cederberg and Mattsson, 2000; Gronroos et al., 2006; Guerci et al., 2013; Hörtenhuber et al., 2010; van der Werf et al., 2009) further analyzed the environmental impacts of using different bean varieties. Meisterling et al. (2009) also compared agricultural impacts on global warming potential (GWP) with transport impacts. Venkat (2012), in addition, analyzed the scenario of converting production of the analyzed products from conventional to organic estimating the potential for sequestering additional organic carbon in the soil. Finally, one study used data from organic and conventional milk production systems to investigate how different LCA modeling approaches can influence the results of milk carbon footprints (Flysjö et al., 2012).

2.3.1.2 Functional unit

Except for the studies of Kavargiris et al. (2009), Litskas et al. (2011), Michos et al. (2012), and Zafiriou et al. (2012), where impacts were related to area only, all of the reviewed studies expressed environmental impacts of the impact categories listed in Table 2.2 as impact per product unit. Three of the studies analyzing milk (Haas et al., 2001; Hörtenhuber et al., 2010; van der Werf et al., 2009), the study of Nemecek et al. (2011a) on arable crops, and the study of Abeliotis et al. (2013) on beans additionally expressed the environmental impacts by area and year.

2.3.1.3 Data basis and sample size

Of the 34 studies, 22 based their comparison on production data from a sample of real farms (Table 2.1). Those studies comparing production systems on nationwide scale used average national statistical data (Basset-Mens and van der Werf, 2005; Hörtenhuber et al., 2010; Leinonen et al., 2012a; Leinonen et al., 2012b; Meisterling et al., 2009; Venkat, 2012; Williams et al., 2006; Williams et al., 2010). One study used statistical data from the horticultural industry (Vermeulen and van der Lans, 2011). One study on field crops used data from long term field trials (Nemecek et al., 2011a). In two cases regional production data was used (Juraske and Sanjuán, 2011; Venkat, 2012), one study compared products from model farms of which data origin was not further specified (Bos et al., 2007), and one study derived the average agricultural practice within a region from producers without mentioning their number (Abeliotis et al., 2013).

Overall, the data basis for production data regarding management practices, inputs, and yields in the reviewed comparative LCAs can be considered to be of high reliability. However, in 18 studies, data were taken from 10 or less farms for one or both farming systems (Table 2.1). In these cases it is questionable whether the results are representative for the farming system. In nine studies, the sample size of conventional farms was larger than the sample size of organic farms while sample size of organic farms was larger in three studies (Table 2.1). Nemecek et al. (2011a) compared arable crops from organic and conventional systems and calculated the average yearly environmental impacts of different crop rotations with rotation cycles of 6 years. Villanueva-Rey et al. (2014) considered two years of production in their analysis of wine grapes. All other studies considered only one year of production.

2.3.1.4 Reported impacts

Three studies showed a higher productivity for organic production systems (Abeliotis et al., 2013; Liu et al., 2010; Venkat, 2012) and in one study the same productivity for organic and conventional was reported (Juraske and Sanjuán, 2011). Out of the 12 crops analyzed in Venkat (2012) higher productivity in organic was only reported for alfalfa, blueberry, raisin and wine grape and apple (for the latter two only in one out of two cases analyzed). In all other studies reviewed productivity of conventional production was higher.

Further, organic products usually had lower environmental impacts on a per area unit across all of the analyzed impact categories. The most noticeable exception was the study of Abeliotis et al. (2013) where impacts of organic beans were also higher on a per area basis for all impact categories analyzed except for aquatic ecotoxicity. The authors attributed the higher impacts to the higher diesel, water, and electricity input per ha in organic. Further exceptions were abiotic resource use, eutrophication and acidification potential for beef, pig and poultry production in Williams et al. (2006) and Alig et al. (2012), energy demand, eutrophication and acidification potential of tomatoes in Williams et al. (2006), eutrophication potential of wheat and potatoes in Williams et al. (2010), acidification potential of wheat and potatoes in Williams et al. (2010) and global warming potential of strawberries in Warner et al. (2010) (Table 2.2, see also Supplementary Material, Appendix A). For the same impact categories and the same commodity, the environmental impacts reported in the reviewed LCA studies varied considerably; e.g. the relative difference between the GWP of organically and conventionally produced milk was found to vary from −67 to −13% per area unit and from −38% to +53% per product unit (Table 2.2).

Table 2.2 Overview of impact categories analyzed per product group and the relative differences between organic and conventional systems in the 26 reviewed studies.

Impact category	Relative difference organic/ conventional on per area unit and year[a]	Relative difference organic / conventional on per product unit[a]	# of studies
Milk			11
Energy demand	−70 to −39%	−56 to −7%	8
Global warming potential (GWP)	−67 to −13%	−38 to +53%	10
Eutrophication potential	−76 to −2%	−66 to +63%	7
Acidification potential	−51 to −2%	−13 to +63%	7
Ecotox terrestrial	−73%	−59%	1
Pesticide use	−100 to −94%	−100 to −89%	3
Productivity	−47 to −6%		11
Land use		+6 to +90%	11
Beef			3
Energy demand	−64 to −22%	−35 to +53%	2
Abiotic resource use	−53%	−14%	1
GWP	−60 to −24%	−15 to +15%	3
Eutrophication potential (aquatic and terrestric combined)	+13%	+108%	1
Eutrophication potential terrestric	+12%	+42%	1
Eutrophication potential aquatic N	−8%	+17%	1
Eutrophication potential aquatic P	−26%	−6%	1
Acidification potential	−34 to +10%	+40 to +82%	2
Ozone vegetation	−61 to −22%	−1 to +8%	1
Ozone human	−58 to −21%	0 to +14%	1
Resource use K	−98 to −90%	−95 to −87%	1
Resource use P	−97 to −96%	−97 to −96%	1
Water use (blue water)	−59 to −33%	−15 to +14%	1
Productivity	−64 to −21%		3
Land use		+27 to +175%	3
Arable land use		−70 to −14%	1
Deforested land use		−98 to 0%	1
Pesticide use	−100%	−100%	1
Ecotox terrestrial incl. pesticides	−99 to −97%	−98 to −96%	1
Ecotox aquatic incl. pesticides	−100 to −99%	−99%	1
Human tox incl. pesticides	−95 to −74%	−86 to −67%	1
Pig			3
Energy demand	−50 to −23%	−13 to +40%	3
Abiotic resource use	−45%	−6%	1
GWP	−41 to −5%	−11 to +73%	3

Impact category	**Relative difference organic/ conventional on per area unit and year**[a]	**Relative difference organic / conventional on per product unit**[a]	**# of studies**
Eutrophication potential (aquatic and terrestric combined)	−67 to −43%	−43 to +4%	2
Eutrophication potential terrestric	+24%	+116%	1
Eutrophication potential aquatic N	0%	+74%	1
Eutrophication potential aquatic P	−54%	−20%	1
Acidification potential	−81 to +12%	−67 to +96%	3
Ozone vegetation	−36%	+12%	1
Ozone human	−34%	+15%	1
Resource use K	−96%	−93%	1
Resource use P	−94%	−89%	1
Water use (blue water)	−45%	−4%	1
Productivity	−45 to −42%		3
Land use		+73 to +82%	3
Arable land use		+82%	1
Deforested land use		−97%	1
Pesticide use	−100 to −90%	−100 to −83%	2
Ecotox terrestrial incl. pesticides	−98%	−96%	1
Ecotox aquatic incl. pesticides	−99%	−98%	1
Human tox incl. pesticides	−92%	−98%	1
Poultry			4
Abiotic resource use	−60 to +56%	+80 to +241%	2
Energy demand	−64 to −32%	+3 to +59%	4
GWP	−71 to −33%	−24 to +46%	4
Eutrophication potential (aquatic and terrestric combined)	−46 to −20%	+76 to +140%	2
Eutrophication potential terrestric	+6%	+140%	1
Eutrophication potential aquatic N	−12%	+100%	1
Eutrophication potential aquatic P	−56%	0%	1
Acidification potential	−56 to −12%	+16 to +100%	4
Ozone vegetation	−48%	+18%	1
Ozone human	−56%	0%	1
Resource use K	−99%	−97%	1
Resource use P	−85%	−67%	1
Water use (blue water)	−93%	−85%	1
Productivity	−78 to −54%		4
Land use		+119 to +346%	4
Arable land use		+124%	1
Deforested land use		−83%	1
Pesticide use	−98 to −96%	−92 to −90%	2
Ecotox terrestrial incl. pesticides	−99%	−98%	1
Ecotox aquatic incl. pesticides	−100%	−99%	1
Human tox incl. pesticides	−93%	−83%	1
Eggs			1
Abiotic resource use	−47%	+122%	1
Energy demand	−63%	+56%	1
GWP	−72%	+17%	1
Eutrophication potential (aquatic and terrestric combined)	−52%	+104%	1
Acidification potential	−59%	+72%	1
Productivity	−76%		1
Land use		+323%	1
Pesticide use	−99%	−96%	1
Fruits & vegetables			13
Abiotic resource use	−89 to +42%	−71 to +89%	3

Impact category	Relative difference organic/ conventional on per area unit and year[a]	Relative difference organic / conventional on per product unit[a]	# of studies
Energy demand	−48 to +54%	−25 to +104%	5
GWP	−90 to +121%	−81 to +130%	8
Eutrophication potential	−96 to +219%	−90 to +323%	3
Acidification potential	−94 to +127%	−83 to +201%	2
Ozone (photochemical oxidation)	−92 to −5%	−79 to +30%	2
Ozone depletion	−94 to −14%	−84 to +17%	2
Ecotox terrestrial	−100%	−99%	2
Productivity	−65 to +76%		12
Ecotox aquatic	−100%	−100%	1
Human tox	−100 to −82%	−100 to −76%	2
Nuts			1
GWP	+18 to +22%	+52 to +490%	1
Arable crops			8
Abiotic resource use	−77 to −17%	−83 to +22%	3
Energy demand	−77 to −21%	−56 to +14%	6
GWP	−69 to −92%	−41 to +45%	8
Eutrophication	−65 to +104%	−62 to +210%	5
Acidification	−84 to +119%	−58 to +66%	5
Ozone (photochemical oxidation)	−91 to −13%	−93 to +9%	2
Ozone depletion	+24 to +32%	0 to +11%	1
Resource use K	−75%	−66%	1
Resource use P	−97%	−96%	1
Pesticide use	−100 to −81%	−100 to −72%	2
Productivity	−68 to +32%		8
Land use		+9 to +214%	4
Ecotox terrestrial	−99 to +25%	−100 to +8%	2
Ecotox aquatic	−87 to −36%	−84 to −25%	1
Ecotox aquatic (freshwater)	−252 to +38%	−0.06 to +0.03%	1
Ecotox aquatic (marine)	+23 to +29%	−2 to +10%	1
Human tox	−65 to −17%	−50 to −2%	2

Environmental impacts on per area unit were calculated if not explicitly given in the studies.
[a] Basis: conventional.

The relative differences between organic and integrated products from the ESU-services Ltd. (Jungbluth et al., 2013) and ecoinvent (v2.2) databases (Nemecek and Kägi, 2007) are listed in Table 2.3. Impacts were calculated with the ecological scarcity method (Frischknecht et al., 2009; Jungbluth et al., 2012). The differences listed in Table 2.3 are within the ranges found in the comparative studies (Table 2.2) for the respective product and impact category or are slightly better for organic: with the exceptions of energy demand for pig and poultry; GWP for pig; eutrophication potential for beef and all fruits and vegetables; acidification potential of tomatoes; and land use of livestock products, fruit and vegetables but without tomatoes, soybean and wheat. Land use impacts for livestock products and fruit and vegetables are less for organically produced products because the biodiversity on the organic fields is higher, which is accounted for in the ecological scarcity method and thus balances the higher land occupation due to lower yields.

Table 2.3 Relative difference between environmental impacts per product unit of selected products from the ESU-services and ecoinvent v.2.2 databases.

	Relative difference organic/integrated on per product unit[a]			
Livestock products[b]	**Milk**	**Beef**	**Pig**	**Poultry**
Energy demand	−5%	−2%	−24%	−8%
Global warming potential (GWP)	−12%	−8%	−25%	−18%
Ozone depletion	−3%	−8%	−39	−17%
Eutrophication potential	−13%	−1%	+4%	+4%
Acidification potential	−12%	−13%	−30%	−21%
Heavy metals, water	−30%	−48%	−81%	−79%
Heavy metals, soil	−165%	−261%	+405%	−79%
Pesticide use	−100%	−99%	−100%	−100%
Water use	−69%	−76%	−73%	−73%
Land use	−1%	−23%	−32%	−32%
Fruits & vegetables[b]	**Tomatoes**	**Carrots**	**Strawberries**	**Pear**
Energy demand	−71%	+12%	+61%	+26%
Global warming potential (GWP)	−78%	−9%	+39%	+10%
Ozone depletion	−69%	−46%	+8%	−50%
Eutrophication potential	−17%	−69%	−65%	−85%
Acidification potential	−86%	+13%	+84%	+17%
Heavy metals, water	−97%	−60%	−25%	+60%
Heavy metals, soil	+306%	+2410%	+5981%	−29%
Pesticide use	−53%	−100%	−96%	−100%
Water use	−28%	+51%	+64%	+5%
Land use	+37%	−38%	−117%	−117%
Arable crops[c]	**Barley grains**	**Soybeans**	**Wheat grains**	**Potatoes**
Energy demand	−6%	−10%	−11%	−5%
Global warming potential (GWP)	+18%	−12%	−9%	+88%
Ozone depletion	−66%	−54%	−81%	−68%
Eutrophication potential	+54%	−26%	+80%	+39%
Acidification potential	−57%	−59%	−59%	−9%
Heavy metals, water	−77%	−65%	−79%	−54%
Heavy metals, soil	+333%	−105%	+665%	+1102%
Pesticide use	−100%	−100%	−100%	−100%
Water use	−65%	−54%	−68%	−12%
Land use	0%	−36%	−4%	+1%

[a] Basis: conventional.

[b] Inventories from LCI database of ESU-services only (Jungbluth et al., 2013).

[c] Inventories from ecoinvent v2.2 (Nemecek and Kägi, 2007).

2.3.1.5 Interpretation of results

Regarding the interpretation of results, only six of the 34 reviewed studies conducted a sensitivity analysis on the choices of emission models or the choices of impact assessment methods, and only seven studies carried out a Monte-Carlo simulation to verify uncertainties within the results (Table 2.4). Six of the 34 reviewed studies concluded that organic farming systems compared to conventional perform better in some impact categories (e.g., non-renewable energy use, GWP, resource use of P and K, ecotoxicity) and worse in others (e.g., GWP, eutrophication and acidification potential) (Table 2.4). Eighteen studies concluded that organic farming has lower environmental impacts, or may have lower impacts in certain cases, for the impact categories analyzed. However, five of these 18 studies referred this conclusion to impacts per area only. Two studies concluded that there are no differences in environmental impacts at product level between organic and conventional farming systems. Finally, four studies drew no conclusions on the environmental performance of the analyzed farming systems because either the focus was on the assessment procedure or no generalization was possible due to small sample sizes.

Table 2.4 Sensitivity and uncertainty analyses of results and main conclusions drawn in the reviewed studies.

Study	**Sensitivity analysis on choices of methods/models**	**Uncertainty analyses of results**	**Main conclusions regarding farming systems**
Abeliotis et al. (2013)	No	No	Integrated agricultural (IP) bean production is preferable among conventional, IP and organic in terms of acidification, eutrophication, and GWP. Organic bean production leads to the protection of abiotic resources.
Alig et al. (2012)	Yes	Yes	Compared to conventional meat production systems organic systems show a lower resource use of P and K and a lower terrestric and aquatic ecotoxicity due to the ban of mineral fertilizers and synthetic pesticides. However, lower yields in organic leads to higher environmental impact per kg meat.
Basset-Mens and van der Werf (2005)	No	Yes	No conclusion on farming systems (focus is on the scenario-based assessment procedure to compare different production systems).
Backer et al. (2009)	No	No	Assessed on area basis organic farming shows a more favorable environmental profile than conventional farming. Due to lower yields in organic farming overall environmental benefits are strongly reduced or disappear on a per product basis.
Boggia et al. (2010)	No	No	System comparison showed that organic systems present the lowest environmental impacts.
Bos et al. (2007)	No	No	Organic dairy farming performs better and organic crop production worse than their conventional counterparts.
Casey and Holden (2006)	No	Yes	Shift from conventional to organic suckler-beef production would reduce GHG emissions in terms of product and area, but at the cost of a large drop in production per hectare.

Study	Sensitivity analysis on choices of methods/models	Uncertainty analyses of results	Main conclusions regarding farming systems
Cederberg and Mattsson (2000)	No	Yes	Organic (i.e. extensive) milk production has environmental benefits (reduced use of pesticides and phosphorus). However, measures to reduce impacts in GWP, acidification and eutrophication have to be implemented for organic and conventional milk production.
Cederberg and Flysjö (2004)	n.a.[a]	No	Two strategies for reducing environmental impacts of milk production: 1) increasing production per cow while optimizing use of input resources (to be favored when land resources are limited). 2) extensive production, e.g. by organic farming (to be favored when land resources are sufficient for large home-based fodder production).
Flysjö et al. (2012)	Yes[b]	No	Increased milk production per cow does not necessarily reduce the GWP of milk when the alternative production of the by-product beef is considered.
Gronroos et al. (2006)	Yes[b]	No	Organic milk and rye bread production in Finland are somewhat less dependent on non-renewable energy sources than conventional. Changing from conventional to organic would be the easiest way to reduce non-renewable energy use in milk production. For rye bread it would be the second best choice since reduction potential within bakeries is even greater.
Guerci et al. (2013)	No	No	Huge variability in environmental impact within farms of a particular farming system due to different structural characteristics and management strategies. No upscaling of results on regional or national level possible due to small sample size. Proportion of grassland in the farming system and the feed efficiency in the herd most strongly influenced the environmental impact.
Haas et al. (2001)	No	No	LCA is suitable to compare farms and farming systems, but further development in methodology is needed.
Hörtenhuber et al. (2010)	No	No	Organic milk production systems have a lower GWP per ha of farmland and per kg of milk. However, site-specific conditions are important: The higher the potential milk output per cow, the lower the differences between compared systems.
Juraske and Sanjuán (2011)	No	No	Organic orange production represents the least toxic pest management alternative for human toxicity and fresh-water ecotoxicity impacts compared to integrated pest management (conventional production).
Kavargiris et al. (2009)	No	No	GWP (of fossil energy only) and non-renewable energy use in organic vineyards is lower than in conventional (on a per area basis). Organic farming systems could be an answer to the objectives of EEB's (European Environmental Bureau) vision for European Agriculture (2008–2020).
Knudsen et al. (2010)	Yes	No	Organic soybeans imported from China to Denmark have lower environmental impact per ton produced than conventional soybeans. However, the transport stage accounts for 51% of GWP.
Kristensen et al. (2011)	No	No	There is a high variation in GWP per kg milk between farms within organic and conventional agriculture. Differences between the average GWP per kg milk from organic and conventional production was negligible.
Leinonen et al. (2012a)	No	Yes	Improving feed efficiency (quantity, composition, nutrient content) has the potential to reduce environmental impacts of broiler production.

Study	Sensitivity analysis on choices of methods/models	Uncertainty analyses of results	Main conclusions regarding farming systems
Leinonen et al. (2012b)	No	Yes	Large differences in many impact categories between the different egg production systems analyzed. These reflect the differences in efficiency in production, feed consumption, and material and energy use. Further, there large variation in impacts between different production units within the same system can be observed.
Litskas et al. (2011)	No	No	Organic cherry production is an efficient way to reduce non-renewable energy input and GHG emissions (of fossil energy and fertilizer production only) in Natura 2000 sites (on a per area basis).
Liu et al. (2010)	Yes	No	Conversion from conventional to organic farming may contribute to the reduction of GHG emissions and non-renewable energy use.
Meisterling et al. (2009)	No	No	When conventional and organic wheat are transported the same distance to market, the organic wheat system produces less GHG emissions. Farming practices such as fuel use, fertilizer management, and tillage matter greatly when discussing the difference between organic and conventional products.
Michos et al. (2012)	No	No	Organic farming holds is an efficient way to reduce (on a per area basis) energy inputs and greenhouse gas-emissions (of fossil energy and fertilizer production only).
Nemecek et al. (2011a)	Yes	No	An overall assessment of organic crops in comparison to integrated crop production (conventional) led to the conclusion that environmental impacts of organic farming are in general equal or lower than impacts of conventional farming.
Thomassen et al. (2008b)	No	No	Organic farms showed lower non-renewable energy use and lower eutrophication potential per kg of milk than conventional farms, but had higher GWP and acidification potential implying that higher NH_3-, CH_4- and N_2O-emissions occur on farm per kg of organic milk.
van der Werf et al. (2009)	No	Yes	Organic farms have lower potential environmental impacts than conventional farms per ha of land occupied, but there are no significant differences in impacts per kg of milk (except for land occupation).
Venkat (2012)	No[c]	No	Average emissions for organic production are higher by 10.6% due to lower yields, higher on farm energy use, the production and delivery of large quantities of compost and the fact that emissions from manufacture of synthetic fertilizers and pesticides used in conventional farming are not large enough of offset the additional emissions in organic farming.
Vermeulen and van der Lans (2011)	No	No	No conclusion on farming systems (study focused on the use of combined heat and power [cogeneration] within organic and conventional tomato production).
Villanueva-Rey et al. (2014)	No	No	Biodynamic viticulture shoed a substantially lower environmental profile for all assessed impacts (except for land use).
Warner et al. (2010)	No	No	It is possible to grow strawberries in low-input systems if cropped in season (without covers), if sufficient land is available to permit a long rotation and if suitable soil conditions are present.
Williams et al. (2006)	No	No	Organic field crops and animal products mostly consume less primary energy than the respective conventional products (except poultry meat and eggs). Regarding GWP, acidification, and eutrophication, organic production often results in increased burdens.

Study	**Sensitivity analysis on choices of methods/models**	**Uncertainty analyses of results**	**Main conclusions regarding farming systems**
Williams et al. (2010)	No	No	Results for conventional production were similar to those from other European studies. However, values for organic systems were higher for the UK compared to other European studies.
Zafiriou et al. (2012)	No	No	Although organic farms showed a great variability regarding GWP (of fossil energy and fertilizer production only) and non-renewable energy use of asparagus production, organic farming can efficiently reduce energy inputs and GHG emissions.

[a] Life Cycle Inventory (LCI) only.

[b] By-product handling.

[c] However, sensitivity analysis on variable distance for transport of inputs to the farm was carried out.

2.3.2 CRITICAL POINTS WITHIN THE GOAL AND SCOPE DEFINITION

Of the reviewed LCA studies, 31 were attributional and three claimed to have considered a consequential perspective (Flysjö et al., 2012; Kristensen et al., 2011; Liu et al., 2010). In attributional LCAs, the analysis gives a description of resource flows and emissions attributed to the functional unit assuming a status quo situation. Consequential LCAs follow a cause-effect chain approach to analyze how pollution and resource flows within a system change in response to change in the provision of the functional unit (Thomassen et al., 2008b). As Earles and Halog (2011) simply put it, consequential LCA represents the convergence of LCA and economic modeling methods. The choice of attributional or consequential LCA strongly determines the choice of co-product handling and, by that, the choice of system boundary. Physical relationships, exergy, energy, mass, or economic allocation are usually used in attributional LCA, while consequential LCA uses system expansion to determine the environmental burden to be attributed to co-products.

Flysjö et al. (2012) and Kristensen et al. (2011) used system expansion when determining the GWP of milk to distribute emissions between milk and meat. They argue that, when comparing organic with conventional milk production, it is important to consider the linkage between milk and beef production because the system specific difference leads to different functions (higher milk and lower meat production in the one case, lower milk and higher meat production in the other). These different functions are usually not considered by attributional LCA: In organic milk production systems cows on average have more lactation periods and therefore deliver more beef meat (Flysjö et al., 2012). Flysjö et al. (2012), in their Swedish study, calculated that 5 g more meat (carcass weight) were produced per kg of organically produced energy corrected milk (ECM). Assuming constant consumption patterns, these 5 g of extra meat per kg of milk have to be compensated by alternative conventional meat production systems: depending on the specific socio-economic context. For Sweden, Flysjö et al. (2012) assumed that beef from suckler cow systems would replace it. Kristensen et al. (2011) assumed, in the case of Denmark, that 50% would be replaced by pork and 50% by beef from suckler cows and intensive steer production.

In the context of GWP mitigation measures, increasing milk yield per cow is a solution to reduce emissions per unit of milk that is often discussed (see Flysjö et al. (2012) and the studies cited therein). This conclusion is mostly based on attributional LCAs that allocate GHG emissions between milk and beef and thereby ignore the link between milk and beef production. Interestingly, when considering the linkage between milk and beef production through system expansion with a consequential perspective, no correlation between GHG emissions per unit of milk and the milk annual yield per cow exists (Flysjö et al., 2012; Zehetmeier et al., 2011). In contrast to attributional LCAs, consequential LCAs have been suggested for the assessment of animal production systems because they can provide insight into the multidimensional, and sometimes conflicting, consequences of different mitigation options (De Boer et al., 2011). Especially when policy related questions with respect to sustainable food systems are addressed, consequential LCA may help to better understand the interrelations of the different farming systems with the market situation and consumption patterns, including the coverage of rebound effects, and by that may lead to more precise conclusions with regard to improvement strategies. Schader et al. (2012) pointed out that the consequential perspective seems to be important in particular in agricultural LCAs as it is better able to catch differences between farming systems: in particular when conclusions are generalized or used as a basis for decision-making by policy makers. This also applies in the context of comparisons between intensive with extensive farming systems.

Flysjö et al. (2012) also applied a consequential approach in the context of calculating GHG emissions from indirect land use change (ILUC). Two attributional approaches, calculating GHG emissions for soy meal production from Brazil, were compared with two consequential approaches to calculate GHG emissions from land use: under the assumption that all land occupation is associated with GHG emissions. ILUC caused by displacement of crops to be grown in other countries is not considered in attributional approaches, whereas an evaluation of this is attempted in the consequential approaches. However, as argued in Flysjö et al. (2012), a limitation of the consequential approaches is that, in the case of Schmidt et al. (2011), the assessment of land use change (LUC) is based merely on land's biological production capacity, which is a great simplification. The method proposed in Audsley et al. (2009) is even more simplified since the same LUC-factor is used for all land. In the real world, decisions on land use and land use change are affected by many factors including economic market conditions, trade patterns and environmental regulations (Flysjö et al., 2012).

To identify options for reducing fossil energy use and GHG emissions, Liu et al. (2010) calculated GWP and energy use for organic and conventional pear production chains in two different regions in China. They used the consequential approach by Dalgaard and Halberg (2007) to distribute the environmental burden of farmyard manure between animal and plant production. Dalgaard and Halberg (2007) argue that the livestock products should be burdened with these extra emissions because manure in plant production causes higher N-emissions than mineral fertilizer if the yield level is set constant. However, to acknowledge the benefit of avoiding the production of mineral fertilizer by using farmyard manure, they also subtracted the emissions from the avoided production of mineral fertilizer from the burden of the livestock products. While citing this approach Liu et al. (2010) argue that, in their analyzed organic pear production chains, they do not need to account for the field emissions of farmyard manure because these burdened the livestock products. However, Dalgaard and Halberg (2007) only burdened livestock production with the extra N-emissions caused by the farmyard manure (compared to mineral fertilizer). Plant production still has to be burdened with the amount of N-equivalent to the amount of N in the avoided mineral fertilizer. This is most probably the reason why, in the study of Liu et al. (2010), GWP of one ton of organic pears was much lower than for conventional pears: even though N-input was higher in the organic pear production systems.

A comparison between different farming systems may become biased in cases where the allocation rule misses reflecting system-specific differences. To improve the quality of comparative LCAs for different agricultural systems, in particular if the aim is to answer policy related questions on what kind of agriculture to support, we suggest using system expansion whenever possible because agricultural production is often associated with co-production and a consequential approach might even better encompass the system under study. Furthermore, if the multifunctionality of agriculture is to be integrated in an assessment, the inclusion of non-commodity outputs is probably easier to accomplish by system expansion.

2.3.3 CRITICAL POINTS WITHIN THE INVENTORY ANALYSIS

2.3.3.1 Nutrient balances vs. calculated N-flows within studies on milk

Nutrient losses from the nitrogen cycle are responsible for many environmental impacts of modern agriculture (Cederberg and Mattsson, 2000) and affect the eutrophication and acidification potential, GHG emissions, and biodiversity. N-emissions result from the N-surplus on farms. N-flows are different in organic and conventional agriculture because external N-inputs on conventional farms are usually higher (by mineral fertilizer use and a higher share of concentrates in feed rations), which results in a higher N-input per hectare. As a consequence of the higher N-input per hectare, a higher N-surplus per hectare is often also found on conventional farms (Dalgaard et al., 2002; de Boer, 2003; Hansen et al., 2000; Knudsen et al., 2006). Surplus-N is the nitrogen that is potentially lost to the environment through different N-emissions. Therefore, total N-losses by emissions cannot exceed N-surplus.

Among the 34 reviewed studies, Haas et al. (2001) and van der Werf et al. (2009) determined farm gate nutrient balances on the inventory level as the starting point for their emissions' calculations, while in Cederberg and Flysjö (2004) and Cederberg and Mattsson (2000), farm gate nutrient balances were used as a reference to the modeled emissions, and so provided an indirect indication for the emissions of nitrogen and phosphorus. Data from nutrient balances and calculated N-losses are summarized from five studies on milk from the 34 reviewed LCAs where the necessary data were provided (Table 2.5).

Table 2.5 Relation of N-surplus and calculated N-emissions in different studies of milk.

	Haas et al. (2001)	**Cederberg and Mattsson (2000)**	**van der Werf et al. (2009)**	**Cederberg and Flysjö (2004)**	**(Thomassen et al., 2008a; Thomassen et al., 2008b)**
N-input[a] organic [kg N/ha a^{-1}]	93	75	73	103	156
N-input conventional [kg N/ha a^{-1}]	128	235	152	224	288
Atmospheric deposition organic [kg N/ha a^{-1}]	20	10	0	8	30
Atmospheric deposition conventional [kg N/ha a^{-1}]	20	10	0	8	26
Total N-input organic [kg N/ha a^{-1}]	113	85	73	111	186
Total N-input conventional [kg N/ha a^{-1}]	148	245	152	232	314
Total N-output[b] organic [kg N/ha a^{-1}]	31	20	35	32	82
Total N-output conventional [kg N/ha a^{-1}]	48	47	64	66	91
N-use efficiency organic [output : input]	27	24	48	29	44
N-use efficiency conventional [output : input]	32	19	42	28	29
NH_3-N organic [kg N/ha a^{-1}]	55	24	13	25	28
NH_3-N conventional [kg N/ha a^{-1}]	68	61	16	39	40
NO_3-N organic [kg N/ha a^{-1}]	31	19	31	26	21
NO_3-N conventional [kg N/ha a^{-1}]	80	32	69	32	64
N_2O-N organic [kg N/ha a^{-1}]	4	1.2	3	3.2	5
N_2O-N conventional [kg N/ha a^{-1}]	6	3.1	4	4.7	7
NO-N organic [kg N/ha a^{-1}]	n.s.	n.s.	n.s.	n.s.	n.s.
NO-N conventional [kg N/ha a^{-1}]	n.s.	n.s.	n.s.	n.s.	n.s.
NO_x-N organic [kg N/ha a^{-1}]	7	n.s.	2	n.s.	n.s.
NO_x-N conventional [kg N/ha a^{-1}]	17	n.s.	3	n.s.	n.s.
Milk yield organic [kg N/ha a^{-1}]	4882	3297	4416	5100	8937
Milk yield conventional [kg N/ha a^{-1}]	7153	7415	7197	9460	14,713
N-surplus[c] organic [kg N/ha a^{-1}]	51	65	38	79	104
N-surplus conventional [kg N/ha a^{-1}]	100	198	88	166	223
Ratio surplus conventional : organic	1.96	3.05	2.30	2.10	2.15
Kg N-surplus/kg milk organic	0.010	0.020	0.009	0.015	0.012
Kg N-surplus/kg milk conventional	0.014	0.027	0.012	0.018	0.015
Ratio surplus conventional : organic	1.34	1.35	1.41	1.13	1.30
Total N from losses[d] organic [kg N/ha]	97	44	49	54	54
Total N from losses conventional [kg N/ha]	172	96	92	76	111
Ratio losses conventional : organic	1.77	2.17	1.89	1.40	2.05
Kg N-losses/kg milk organic	0.020	0.013	0.011	0.011	0.006
Kg N-losses/kg milk conventional	0.024	0.013	0.013	0.008	0.008

	Haas et al. (2001)	Cederberg and Mattsson (2000)	van der Werf et al. (2009)	Cederberg and Flysjö (2004)	(Thomassen et al., 2008a; Thomassen et al., 2008b)
Ratio losses conventional : organic	1.21	0.97	1.16	0.75	1.24
Share of N-surplus found in N-losses organic	190%	68%	128%	69%	52%
Share of N-surplus found in N-losses conventional	172%	49%	105%	46%	50%
Relative difference in reported eutrophication potential between organic and conventional milk on a per amount of product basis	−66%	+9%	−30%	+35%	−36%

[a] N-inputs at farm gate as seeds, feed, straw, mineral fertilizer, imported manure, N-fixation, cattle.
[b] N-outputs at farm gate as products, exported manure.
[c] Balance between N-input (from fertilizers, feed import, N-fixation, N-deposition) and N output (as animal and plant products).
[d] Sum of NH_3, NO_3, N_2O, NO, NO_x.

In all five studies listed in Table 2.5, N-surplus per hectare on organic farms was two to three times lower than on conventional farms. When dividing the N-surplus per hectare by the milk yield per hectare, the amount of surplus-N per kg milk was still lower for organic milk in all five studies. This result suggests that the overall N-losses due to emissions per kg milk should also be lower in organic systems. Calculated N-losses per hectare still were lower for organic production across all five studies. However, this changed in two cases when the N-losses per hectare were divided by the milk yield per hectare (Cederberg and Flysjö, 2004; Cederberg and Mattsson, 2000). Cederberg and Mattsson (2000) reported that N-losses per milk yield per hectare became equal for organic and conventional and Cederberg and Flysjö (2004) reported that N-losses per milk yield in organic production systems exceeded those of conventional systems (Table 2.5). In these two studies, the eutrophication potential was reported as 9 and 35% higher per kg of organic milk respectively: even though the N-surplus per kg milk was lower in the organic systems. As a consequence of the lower N-surplus in the organic systems, eutrophication potential per kg of organic milk should be lower too.

Interestingly, when calculating the share of N-losses from N-surplus, the calculated N-losses did not equal N-surplus in any of the studies: neither for organic nor for conventional production systems (Table 2.5). In two cases the calculated N-losses exceeded the amount of N-surplus for both organic and conventional systems (Haas et al., 2001; van der Werf et al., 2009). In all other cases, the calculated N-losses for organic systems made up 52–69% of the N-surplus whereas the calculated N-losses only amounted to 46–50% of the surplus-N for conventional milk production in the corresponding cases.

This analysis indicates that the models for calculating N-losses in LCAs need to be improved to better account for the N-surplus and, in particular, that the models have to be adapted to better reflect organic production systems. Cederberg and Flysjö (2004) stress that models used to calculate N-losses are probably not fully adapted for organic production systems. Therefore, in comparative LCAs of farming systems, it should be critically examined whether a higher eutrophication and acidification potential per product unit in organic farming systems is really due to lower yields: as is often argued. In cases where the N-surplus per product unit in extensive farming systems is lower than in intensive farming systems, the eutrophication potential per product unit should also be lower. In fact, N-surplus could be used as a cross reference to check for plausibility of calculated N-losses.

2.3.3.2 Nutrient balances vs. calculated N-flows within ecoinvent processes

To analyze how calculated N-losses correspond with surplus-N from N-balances in ecoinvent inventories (v2.2), we transformed the inventories for the four crops listed in Table 2.6 from emissions per kg to emissions per ha by multiplying the emissions in the inventory by the yield of the respective crop. Thereby, for wheat and barley, we considered that the inventories per kg comprised an economic allocation step between grains and straw. The inventories for the four crops represent Swiss agricultural practice and are available for organic and integrated production (IP). Furthermore, we determined N-input and -output as well as N-losses per ha from the data given in the inventories (Table 2.6). We then calculated the N-balance by considering the total N-content for organic fertilizers (slurry, solid manure). The N-surplus and, accordingly, N-losses were always higher in the organic crops than in IP systems except for the case of soybeans (Table 2.6). However, in all inventories, independent of the farming system, N-losses calculated by emission models exceeded N-surplus by a factor of 1.7–3.6 (Table 2.6) whereas N from nitrate emissions made up 74–90% of total N-losses. The main reason for this imbalance is probably that the nitrate leaching model used within the inventories also includes nitrogen mineralization from soil organic matter (Nemececk and Schnetzer, 2011; Nemecek and Kägi, 2007; Richner et al., 2006). The additional nitrogen from mineralization is not considered in the nitrate emission calculation in the N-balances in Table 2.6. However, while N-mineralization is considered for the calculation of the nitrate leaching potential, this is not the case in the model for calculating N_2O-emissions. Furthermore, as described in Richner et al. (2006), the nitrate leaching model does not consider losses from denitrification (N_2 and N_2O). This actually means that some of the N in the losses is counted twice. From the situation outlined above, again it becomes obvious that N-emission models used to calculate N-losses within inventories need to be improved and adjusted to the actual N-flows within different agricultural systems.

Table 2.6 N-balance vs. N-surplus in ecoinvent inventories (v2.2) of arable crops at Swiss farms [kg N/ha* a^{-1}].

	Wheat grains		**Barley grains**		**Soybeans**		**Potatoes**	
	Organic	**IP**	**Organic**	**IP**	**Organic**	**IP**	**Organic**	**IP**
Slurry spreading[a], by vacuum tanker/CH U	86.1	5.6	69.2	11.7	6.7	16.2	18.4	22.5
Solid manure[b] loading and spreading, by hydraulic loader and spreader/CH U	35.5	0.5	28.5	8.8	13.3	11.0	65.1	70.6
Seeds (organic, at regional storehouse/CH U, IP at regional storehouse/CH U respectively)	4.0	3.6	2.1	1.6	7.2	6.6	5.8	5.8
Ammonium nitrate, as N, at regional storehouse/RER U		67.1		48.5		0.0		16.9
Urea, as N, at regional storehouse/RER U		23.6		17.0		0.0		5.9
Diammonium phosphate, as N, at regional storehouse/RER U		7.0		6.6		0.0		1.0
Calcium ammonium nitrate, as N, at regional storehouse/RER U		33.7		24.3		0.0		8.5
Ammonium sulfate, as N, at regional storehouse/RER U		5.1		3.7		0.0		1.3
N-fixation[c]					143.5	150.0		
N-Deposition[d]	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Total N-input (sum of all above N-inputs)	*151*	*171*	*125*	*147*	*196*	*209*	*114*	*158*
Yield main product	79.3	129.6	61.6	101.3	168.4	176.0	68.7	113.3
Straw	16.9	12.3	12.7	15.6				
Total N-output	*96*	*142*	*74*	*117*	*168*	*176*	*69*	*113*
N-surplus	*54*	*29*	*50*	*30*	*27*	*33*	*46*	*44*
NH_3-N	27.9	7.5	24.1	7.9	2.8	4.7	12.9	15.1
NO_x-N	0.5	0.6	0.5	0.4	0.7	0.7	0.3	0.4
N_2O-N	3.1	3.9	3.0	2.7	4.4	4.7	2.2	2.6
NO_3-N	90.4	74.9	91.7	96.1	43.9	45.2	66.0	59.1
Total N-losses	*122*	*87*	*119*	*107*	*52*	*55*	*81*	*77*
Share of N-surplus found in N-losses [%]	224	296	236	352	190	169	179	174
kg N-losses/kg yield (main product)	0.030	0.014	0.029	0.016	0.018	0.019	0.004	0.002
kg N-surplus/kg yield (main product)	0.013	0.005	0.012	0.004	0.010	0.011	0.002	0.001

[a] Slurry composition according to Nemecek et al. (2005); N-content (N_{tot}) according to Walther et al. (2001); dilution 1:1.5.

[b] Solid manure composition according to Nemecek et al. (2005); N-content (N_{tot}) according to Walther et al. (2001).

[c] Assumed as 150 kg N/ha for conventional, yield adjusted for organic.

[d] Assumed as 25 kg/ha/a.

2.3.3.3 Differentiation of dietary N-flows within livestock production systems

Important differences between extensive and intensive livestock production systems are different dietary compositions that lead to different environmental impacts. In particular, dietary composition affects N-excretion and thereby influences N-emissions from manure (Klevenhusen et al., 2011). The level of excreted N strongly depends on the relationship between the amount of crude protein (CP) that is fed and the amount of dietary N built into milk and body mass (Külling et al., 2001). Ruminal N-use efficiency is determined by the optimal ratio of degradable carbohydrates and the CP content.

As our review revealed, the relationship between the N-content in the diet and the N-content in the excrement is hardly ever considered in LCA inventories and might be an important reason why some of the surplus-N remains unaccounted for in LCAs of milk (see Section 2.3.3.1) and beef (see later this section). From the reviewed studies of milk and beef production, only van der Werf et al. (2009) considered that a higher protein content in the feed ration leads to a higher nitrogen content within the excrement. Ryan et al. (2011), in their study of dairy production systems showed that, even though an increase of N-input in the diet leads to an increase in N-output in the form of production (i.e. milk), 40% of the extra N-input was lost to the environment. Regardless of the production system, more than 70% of the N consumed is excreted via urine as ammonia (Orr et al., 2012; Ryan et al., 2011). Higher ammonia emissions affect the GWP, as well as the eutrophication and acidification potential. Since, in conventional agriculture, feed rations have a higher average protein content (Alig et al., 2012), higher ammonia emissions from excrement should be attributed to conventional agriculture. Orr et al. (2012) reported that a 2.7 fold increase of N-content in the diet led to a 1.8 fold increase of N-excreted in urine. Cederberg and Mattsson (2000) concluded that the calculation of N-losses by emission models, and especially ammonia emissions, seemed to be the most uncertain. In their study, 90% of the acidification potential was due to ammonia losses in organic and conventional systems and, within the eutrophication potential, ammonia accounted for approximately 50%. A better adaptation of ammonia emission models to different farming systems, including taking the diet-related N-flows into account, would, therefore, lead to more accurate estimates for acidification, eutrophication and GWP within comparative LCAs of animal products.

The degree to which dietary compositions may influence N-flows in different farming systems could be demonstrated using the information provided in Alig et al. (2012), where organic and conventional steer production systems in Switzerland were compared. Even though different dietary compositions between organic and conventional steer production were considered to account for different environmental impacts from feed production and for different formations of enteric CH_4 in the cattle, the influence of different dietary compositions on the N-excretion was neglected. Instead, the same annual N-excretion rate per beef production unit of 33 kg N y^{-1} was assumed for organic and conventional steer production systems (Table 2.7). Based on this assumption, and due to the longer time needed to gain the slaughter weight in the organic system, 1 kg of beef (LW) in the organic system produced 43% higher N-excretions than 1 kg of beef (LW) in the conventional system (Table 2.7). However, from the differences in dietary composition between the organic and the conventional steer production system, it is hardly possible that this would result in the same annual N-excretion rate. We, therefore, calculated the amount of N-excreted in the two systems, based on the dietary compositions given in Alig et al. (2012), by adding the crude protein (CP) content of the different ingredients and subtracting the amount of N that was built into biomass. The latter was determined by summing the rumen degradable protein (RDP) of each dietary component. CP and RDP values were taken from the Swiss database on animal feed (http://www.feed-alp.admin.ch/start.php). Despite the higher digestibility of the CP in concentrates, this led to an annual N-excretion rate per beef production unit of 44 kg N a^{-1} in the conventional system vs. 34 kg N a^{-1} in the organic system. Relating the differences in N-excretion rates to the amount of N-excreted per kg of beef (LW) results in a calculated difference between the organic and the conventional system of 18% (Table 2.7), which is half of the difference reported in Alig et al. (2012).

Table 2.7 N-excretion rate assumed in Alig et al. (2012) for Swiss steer production systems and recalculated from dietary N-intake.

	Swiss beef production		**Relative difference**[a]
	Conventional	**Organic**	
Age of slaughter [Mt] as given in study	15	22	
End of life weight [kg LW] as given in study	525	538	
N excretion per kg live weight as given in study [g N/kg LW]	79	112	43%
N-uptake based on CP[b] intake from roughage [kg N/cattle]	35.3	78.0	
N-uptake based on CP intake from concentrates [kg N/cattle]	36.1	7.2	
Total N-uptake based on CP intake [kg N/cattle]	71.4	85.2	
Total N-retention in body mass [kg N/cattle]	11.6	12.7	
Total N-excreted [kg N/cattle]	59.8	72.5	
Annual N-excretion rate per production unit [kg N/a]	44	34	
N-excretion per kg live weight [g N/kg LW]	114	135	18%

[a] Basis conventional.
[b] Crude protein.

Assuming the same annual N-excretion rate per animal in both systems would mean that, in the extensive system due to a rearing phase that is one and a half times longer, the cattle would also eat one and a half times more protein as in the intensive system. If this was the case, then the end of life weight within the extensive system should be considerably higher than in the intensive system: despite the lower fodder use efficiency in the extensive system (which is 0.16 vs. 0.2 in the intensive system) due to the higher share of roughage in the diet. By simplifying assumptions, a system difference was generated that was twice the difference calculated using N-excretion rates specific for organic and conventional farming.

As a consequence of different N-excretion rates between different farming systems, average N-values in manure can be expected to differ between organic and conventional agriculture as well. This in turn leads to different N-emissions from manure storage and from crop production. However, N-contents in manure from organic and conventional agriculture were not differentiated in any of the comparative LCA studies reviewed.

In contrast to the observation that the diet related effects on N-flows have hardly been considered in LCAs so far, the influence of different diets on CH_4 production from enteric fermentation is often differentiated between organic and conventional milk and beef production systems (Table 2.8). Higher CH_4 emissions are attributed to organic agriculture due to forage based diets. However, if different CH_4 emissions are considered from enteric fermentation based on different diets, different CH_4 emissions during manure storage should be considered as well. Concentrates in the diet increase the content of undigested nutrients in manure, which may be transformed to CH_4 by microbial degradation. This may compensate for diet-related mitigation achievements in the animal (Klevenhusen et al., 2011). Hindrichsen et al. (2006) showed that CH_4 emissions from slurry increased when dairy cows were fed mixed forage-concentrate diets instead of forage-only diets. Despite this evidence from experimental studies none of the reviewed comparative LCAs on milk and beef considered diet-dependent CH_4 emissions from manure during storage.

Table 2.8 Diet-related differentiation of enteric fermentation in LCAs on milk and beef.

	Total # of studies	# of studies differentiating emission factors for enteric fermentation	Emission factors based on (Kirchgeßner et al., 1993; Kirchgeßner et al., 1995)	Emission factors based on (IPCC, 2006) (tier 2)	Others
# of studies for milk	9	7	4	2	3
# of studies for beef	3	2	1	1	1

In contrast, newer studies even challenge the widespread assumption that forage-only diets necessarily result in higher enteric CH_4 formation than mixed forage-concentrate diets (Klevenhusen et al., 2011). This means that the GWP of forage-based milk and beef production systems in LCAs have been overestimated in those cases where different emission factors for enteric fermentation based on diet composition were used and where emissions of manure storage was not differentiated for diet compositions.

2.3.4 CRITICAL POINTS WITHIN THE IMPACT ASSESSMENT

Of the 34 studies, 10 analyzed the global warming potential (GWP) only (carbon footprint (CF) studies) (Bos et al., 2007; Casey and Holden, 2006; Flysjö et al., 2012; Hörtenhuber et al., 2010; Kristensen et al., 2011; Liu et al., 2010; Meisterling et al., 2009; Venkat, 2012; Vermeulen and van der Lans, 2011; Warner et al., 2010) [see Supplementary Material, Appendix A for a tabular overview]. Five studies focused on energy demand (Gronroos et al., 2006; Kavargiris et al., 2009; Litskas et al., 2011; Michos et al., 2012; Zafiriou et al., 2012). In addition to energy demand Kavargiris et al. (2009), Litskas et al. (2011), Michos et al. (2012) and Zafiriou et al. (2012) also quantified greenhouse gas emissions from fossil fuel use and fertilizer production. However, N_2O-emissions from soils were not included. From these studies we, therefore, only considered energy demand in this review. Further, one study examined toxicity (human toxicity and freshwater ecotoxicity) (Juraske and Sanjuán, 2011). The remaining 18 studies analyzed at least eutrophication and acidification potential in addition to GWP. Of these 18 studies, nine studies assessed a wider range of environmental impacts that can be routinely assessed today using LCA (Abeliotis et al., 2013; Alig et al., 2012; Backer et al., 2009; Leinonen et al., 2012a; Leinonen et al., 2012b; Nemecek et al., 2011a; Villanueva-Rey et al., 2014; Williams et al., 2006; Williams et al., 2010). Biodiversity impacts were assessed in Alig et al. (2012) and Nemecek et al. (2011a), using the LCIA-method "SALCA-BD" (Jeanneret et al., 2009; Jeanneret et al., 2014), in Guerci et al. (2013) using biodiversity damage scores as proposed by De Schryver et al. (2010), and in Haas et al. (2001) where impact on biodiversity was qualitatively judged based on self-defined criteria. However, all four studies the impact on biodiversity was assessed for only part of the life cycle of the specific products and was determined on a per area unit only except in Guerci et al. (2013) where land use impacts were related to the production of 1 kg of milk.

Impacts of cultivation practices on soil quality were assessed in Nemecek et al. (2011a) who applied the LCIA-method “SALCA-SQ” (Oberholzer et al., 2006) with impacts related to area.

The above analysis shows that comparative LCAs of agricultural products are far from a comprehensive environmental assessment. The environmental assessment was restricted to only one single impact category in almost half of the studies reviewed. However, important environmental impacts of farming systems, such as effects on biodiversity and soil quality, are not routinely assessed by LCA due to a lack of appropriate impact assessment methods and are, therefore, usually lacking in contemporary comparative LCAs (Cederberg and Mattsson, 2000; Finnveden et al., 2009; Reap et al., 2008; Schader et al., 2012). The impact on biodiversity was considered in only four studies (Alig et al., 2012; Guerci et al., 2013; Haas et al., 2001; Nemecek et al., 2011a). However, the applied impact assessment methods do not allow for a comprehensive assessment that covers the entire life cycle because they only assess the biodiversity impacts of the agricultural production phase.

A difference between organic and conventional farming is that no synthetic pesticides are used within organic farming. Toxicity related impacts (human toxicity, terrestrial ecotoxicity, freshwater and marine aquatic ecotoxicity) were reported in nine of the reviewed studies (Abeliotis et al., 2013; Alig et al., 2012; Backer et al., 2009; Basset-Mens and van der Werf, 2005; Boggia et al., 2010; Juraske and Sanjuán, 2011; Nemecek et al., 2011a; van der Werf et al., 2009; Villanueva-Rey et al., 2014). Four different LCIA methods (CML, 2000, Eco-indicator 99, EDIP97, and USEtox) were used, including mid- and endpoint characterization methods. Impacts calculated for organic systems were always lower (−20% to −100%) than those reported for conventional systems except for the assessment of beans in Abeliotis et al. (2013) were higher impacts for terrestrial and aquatic (freshwater and marine) ecotoxicity were attributed to organic. The usually lower toxicity impacts in organic can mainly be explained by the usual application of synthetic pesticides in conventional systems which lead to higher toxicity scores. However, the availability of characterization factors for biological/natural and inorganic pesticides, which are partly registered for use in organic agriculture, is still generally lacking. Therefore, a thorough comparison of the two agricultural systems is not always possible and might underestimate the impacts in the organic system when these compounds are not included in the LCA: “lack of data” is the most stated reason in the reviewed studies. Recent developments, such as PestLCI 2.0 (Dijkman et al., 2012) on an inventory level and dynamiCROP (Fantke et al., 2011) on the impact assessment level, in combination with an increasing availability of physicochemical and toxicological data, might help in improving the analysis of toxic impacts due to emission of pesticides in the future.

2.4 CONCLUSIONS

LCA, by definition, does not compare products but product systems (ISO, 2006). As for a certain industrial product an agricultural product, too may be produced in different production processes, i.e. different farming systems. In this sense, a comparison of organic vs. conventional products is inevitably a comparison of organic vs. conventional farming systems. So, the comparison of the environmental impact of organic vs. conventional products using LCA must reflect the impacts of these different ways of production adequately.

However, from the 34 reviewed LCA studies, which compared products from organic and conventional farming systems, it is not yet possible to draw a conclusive picture on the general environmental performance of the different farming systems. An important reason for this is that comparative LCAs on agricultural products from different farming systems often do not adequately differentiate the specific characteristics of organic and conventional farming on the inventory level. This is in accordance with the conclusion from an expert workshop on the "Definition of Best Indicators for Biodiversity and Soil Quality for Life Cycle Assessment (LCA)", which pointed out the importance of more detailed assessments to illustrate the effects of different management practices (e.g. organic vs. conventional crops) (Milà i Canals et al., 2006). For example, the nitrogen emissions' calculations are especially often based on the same assumptions for both farming systems although different assumptions should actually be taken. Often assumptions taken for the organic system are based on the values for conventional agriculture. Unfortunately the adaptation of emission models to extensive farming systems is sometimes hindered by a lack of reliable background data from these systems.

Regarding the assessment and comparison of products from different farming systems with LCA we identified potential for methodological improvements at two levels:

First, physical relationships between agricultural products and environmental effects as accounted for in attributional LCAs need to be differentiated more precisely between farming systems and more comprehensively regarding the relevant impact categories. Certainly, there are differences between farming systems that can easily be incorporated in LCA as for example different inputs (fertilizers, pesticides, etc.) used within the two farming systems. Some differences between organic and conventional farming systems, though, are still rather difficult to be integrated in LCA as for example effects on biodiversity and soil quality or the multifunctionality of agriculture. Agriculture is widely seen as a multifunctional production process (OECD, 2001) which, in addition to food, feed and resources for energy production, provides non-commodity outputs such as landscape provision and ecosystem services to society. However, contemporary LCA studies focus on the environmental friendliness of agricultural products: expressing impacts per unit of product without allocation between commodity and non-commodity outputs. This narrow view, which focuses mainly on production efficiency, may often favor products from intensive production systems, although these systems have been shown by other assessment methods to be not environmentally sustainable (Geiger et al., 2010; Gibbs et al., 2009; Meehan et al., 2011). For an LCA-based comparison of farming systems beyond product level, it is necessary to either use different functional units to acknowledge these multifunctional outputs or to allocate the environmental impacts to the whole set of outputs that agriculture provides (Schader et al., 2012).

Second, to answer questions on environmental impacts of agricultural production systems that go beyond the physical relationships, i.e. policy- and environmental management related questions, consequential LCA approaches need to be considered that incorporate economic phenomena such as market elasticity, rebound effects, etc. Even though, it is not always straightforward to integrate economic phenomena into an engineering approach such as LCA.

Conclusions that have been drawn on the environmental performance of organic and conventional farming systems, based on comparative LCAs, should be reconsidered in light of the shortcomings identified within this review. Future comparative LCAs of farming systems must be improved accordingly.

2.5 RECOMMENDATIONS

Based on our analyses within this review, we suggest the following recommendations to improve LCA for comparison of products from different farming systems:

1. Since N-fluxes may be different between farming systems (in particular between extensive and intensive systems) and the human induced nitrogen cycle has environmental impacts on different levels, N-fluxes should be differentiated in more detail. Using N-balances at farm, farming branch or field level could serve as a cross-reference for calculated N-losses.
2. In animal production systems, different production intensities are reflected in the feed ration composition, which leads to different nutrient and C-composition within the excrement. Thus, emissions during farmyard manure management and farmyard manure fertilization in plant production should be adjusted to the respective production intensity: as is often done for enteric fermentation.
3. There is a need to improve N- and C-emission models for farmyard manure management and fertilization. Changes in N- and C-stocks in soils are influenced by different farming practices and fertilizer types, which should be reflected in the emission models. First suggestions have been made for the modeling of N_2O-emissions from soils (Meier et al., 2014; Meier et al., 2012).
4. More background data on extensive farming systems should be generated and compiled so as to be available for use within LCA inventories (e.g. representative concentrations of nitrogen within farmyard manure from organic farms, nitrogen content within organic plant products, nitrogen excretion rates of animals under different feeding intensities, reliable CH_4- and N_2O-emission measurements from farmyard manure storage under different feeding regimes [concentrate vs. forage based rations]). In cases where no reliable background data is available, and data from intensive farming systems are taken instead; this should be clearly stated.
5. Consequential LCA approaches should be used in cases where LCA is used for analyzing different agricultural production systems to find answers for policy-making or strategic environmental planning. Accordingly, system expansion should be applied for co-product handling to fully account of the different functions of the analyzed farming systems.

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LIFE CYCLE INVENTORY AND CARBON AND WATER FOODPRINT OF FRUITS AND VEGETABLES: APPLICATION TO A SWISS RETAILER

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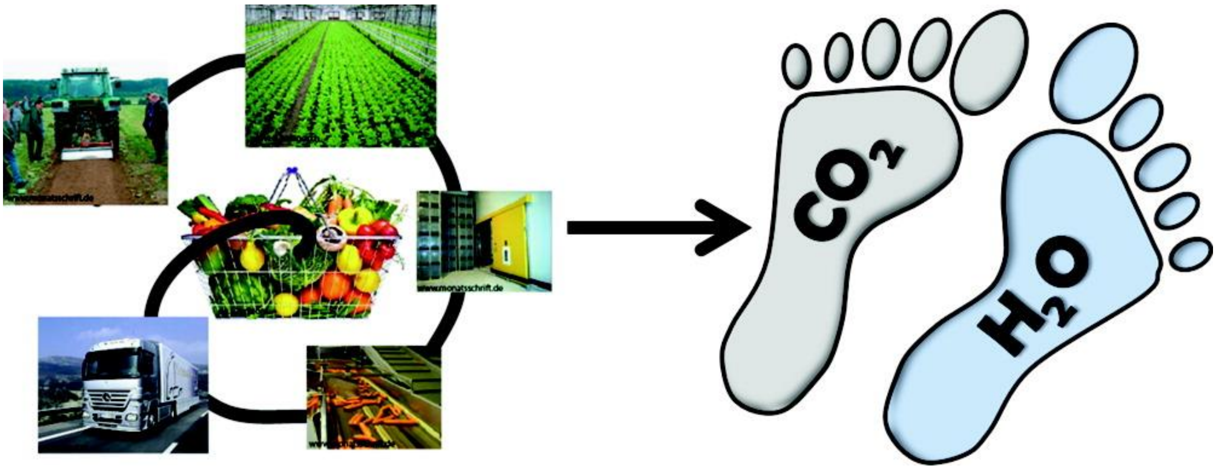

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The individual contribution of Franziska Stoessel consisted of collection and preparing the data, conducting the analyses and preparing the manuscript for publication.

ABSTRACT

Food production and consumption is known to have significant environmental impacts. In the present work, the life cycle assessment methodology is used for the environmental assessment of an assortment of 34 fruits and vegetables of a large Swiss retailer, with the aim of providing environmental decision-support to the retailer and establishing life cycle inventories (LCI) also applicable to other case studies. The LCI includes, among others, seedling production, farm machinery use, fuels for the heating of greenhouses, irrigation, fertilizers, pesticides, storage and transport to and within Switzerland. The results show that the largest reduction of environmental impacts can be achieved by consuming seasonal fruits and vegetables, followed by reduction of transport by airplane. Sourcing fruits and vegetables locally is only a good strategy to reduce the carbon footprint if no greenhouse heating with fossil fuels is involved. The impact of water consumption depends on the location of agricultural production. For some crops a trade-off between the carbon footprint and the induced water stress is observed. The results were used by the retailer to support the purchasing decisions and improve the supply chain management.

3.1 INTRODUCTION

Recent studies have shown that food production and consumption are responsible for 10–30% of an individual’s total environmental impact (Hertwich and Peters, 2009; Känzig and Jolliet, 2006; Tukker and Jansen, 2006). A considerable amount of the total food intake by mass (30%) is represented by fruits and vegetables, which constitute the largest food group consumed worldwide (Juraske et al., 2009). The effects of their production are revealed in different categories of environmental impacts, like climate change, impacts of land and water use, human- and eco-toxicological effects, eutrophication, acidification, soil fertility degradation, and landscape changes. Policy makers and private companies in various countries have recognized the need to quantify these environmental impacts and, on this basis, to identify measures for impact reduction. For instance, a new law in France (Cros et al., 2010) and a recommendation of the Swiss Federal Office for the Environment (Jungbluth et al., 2011) encourage the labeling of food products with their carbon/environmental footprints. Private companies, such as Tesco and Walmart, calculate the carbon footprint of some of their products and communicate these to their customers (Sundarakani et al., 2010), while others use such environmental information for internal decision making regarding products and supply chain management (Coop Group, 2011). Finally, water footprint studies have gained high interest in the area of food production (Chapagain and Hoekstra, 2004; Ridoutt and Pfister, 2010), revealing the amounts of water consumption and the related impacts. The International Organization for Standardization (ISO) is therefore currently considering a standard on water footprint to allow consistent analysis and reporting for product labeling (International Organization for Standardization (ISO), 2011). Despite these initiatives there are still large data gaps concerning the environmental assessment of food products. For instance, while several life cycle assessment (LCA) studies on a variety of fruits and vegetables have been published (Anton et al., 2005; Blanke and Burdick, 2005a; Jungbluth, 2000; Lagerberg and Brown, 1999; Milà i Canals et al., 2006; Munoz et al., 2008), the comparability of these studies is compromised by differences in system boundaries and background data. In contrast to process-based LCA studies, input-output LCA studies (Tukker et al., 2006; Weber and Matthews, 2008) provide data on total food consumption without having cut-offs in the supply chain, leading to a large gap in the overall impacts. Such studies help to identify relevant food groups, but the data are given on an industrial-sector resolution and hence do not allow for identifying improvement potentials within sectors. Moreover, international trade is not well captured due to inconsistencies in the underlying statistical data. Thus, in addition to these studies, detailed, process-based LCA data are needed to support decisions regarding adequate sourcing of food products, means of transportation, agricultural management, and, finally, choices between different food commodities. The goals of the present study were (a) to elaborate a consistent and up-to-date life cycle inventory (LCI) of a large range of fruits and vegetables from different origins, (b) to show selected life cycle impact assessment (LCIA) results and derive general decision guidelines for producers, retailers, policy makers and consumers on how to improve the environmental impacts of fruit and vegetable consumption, and (c) to illustrate and discuss the implementation of these guidelines for a specific case of purchasing decision and environmental supply chain management of a main Swiss retailer.

3.2 MATERIAL AND METHODS

3.2.1 SYSTEM BOUNDARIES

The functional unit (FU) was defined as 1 kg of product at the point of sale. The LCA study includes the following fruits and vegetables: apple, avocado, banana, broccoli, cabbage for conserves, carrots, cauliflower, celery root, citrus fruits, cucumbers, eggplant, fennel, grape, green asparagus, bell pepper, iceberg lettuce, kiwi, lettuce, melon, onion, vine tomatoes, papaya, pear, pineapple, potatoes (LCI adapted from ecoinvent (Ecoinvent, 2008)), radish, red cabbage, round carrots, spinach, strawberries, tomatoes, white asparagus, white cabbage, and zucchini. These products cover more than 80% of the fruits and vegetables sold by one of the two major retailers in Switzerland in 2007, for which the study was originally undertaken. The products were either produced locally or transported to Switzerland from 29 different countries. The LCI were compiled by extrapolating from a basic set of data for one product to the same product from other origins by varying parameters, such as transport means and distances, irrigation, heating energy for greenhouse production, and cooling energy for storage. Inputs and outputs from packaging and the operation of the store were excluded from the analysis as these were shown to be relatively low compared to the overall impact (Appendix B, Section 9.1.1) and equal for all fruits and vegetables. Vegetables, apples, pears and strawberries were modeled using the Swiss agricultural standard production scheme called "integrated production" as described elsewhere (Nemecek et al., 2011). The other fruits were produced according to the so-called "conventional production". The system boundaries are shown in Figure 3.1.

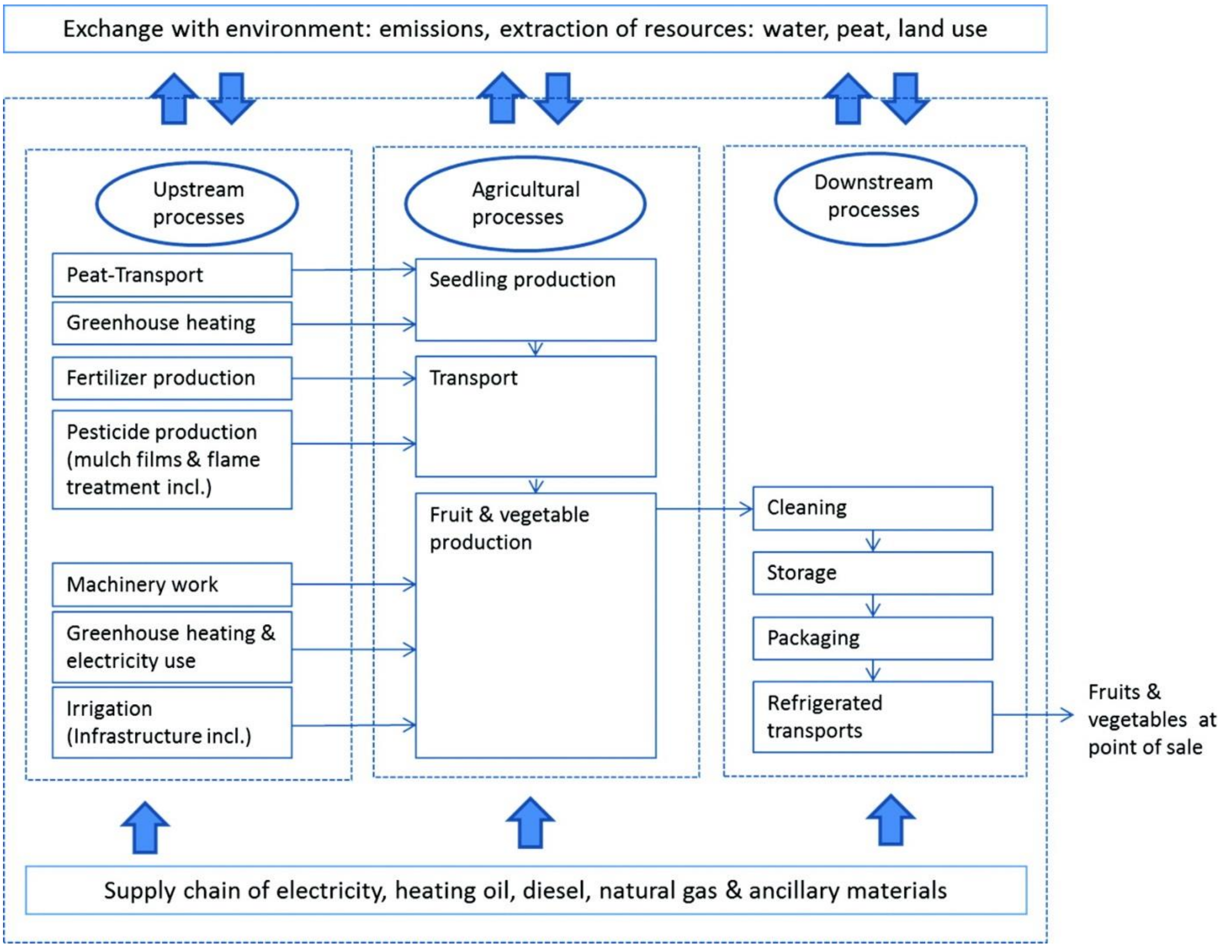


Figure 3.1 System boundaries for cradle-to-gate fruit and vegetable production.

3.2.2 DATA SOURCES AND ASSUMPTIONS FOR LCI ANALYSIS

Tables with agricultural production means for cost calculations were used to set up the inventory of vegetables (Arbeitsgruppe Betriebswirtschaft VSGP, 2005), apples and pears (Bravin et al., 2007), whereas for tropical fruit production additional data were obtained from literature and leaflets of agricultural extension services (Appendix B, Section 9.1.2). Good agricultural practice (GAP) was assumed for all agricultural activities, irrespective of the production site, assuming common global standards throughout the supply chain. This assumption was in accordance with the commissioner of the study, but may need to be revised in cases in which retailers do not make sure that GAP is applied. Modeling was done with SimaPro 7 using background processes from ecoinvent v. 2.01 (Ecoinvent, 2008). Next, a short outline of every parameter considered in the LCI is given; detailed information can be found in the Appendix B, Section 9.3.

3.2.3 YIELDS/LAND USE

It was assumed that the land occupied is arable and that it had been used for agriculture for a long time. Therefore no impacts caused by land transformation were taken into account. Land occupation was calculated based on yield and cultivation time per kg of product (Appendix B, Section 9.1.3).

3.2.4 VEGETABLE SEEDLINGS

One of the upstream processes of vegetable growing is the production of seedlings, which are young plants to be bedded out. They are grown in pots, mainly filled with peat. In this study we assumed an average size of 20 cm^3 per pot (HerkuPlast Kubern GmbH, 2007) with an estimated weight of 20 g. Based on the yield and number of seedlings planted per ha, the amount of peat and the transported weight per kg of product from the mining site were calculated.

Seedling production in Switzerland or further North is generally assumed to take place in heated greenhouses over five weeks. For heating oil consumption, the data for eggplants were assumed for all vegetable seedlings because of similar temperature requirements.

3.2.5 FERTILIZATION

The nutrients, extracted by the plants, eroded and leached to water, have to be replaced by soil fertilization. Here we considered effective fertilization with macronutrients using the ecoinvent processes “ammonium nitrate”, “single superphosphate as P_2O_5” and “potassium sulphate” (Appendix B, Section 9.1.5).

3.2.6 PESTICIDE USE

The use of 84 pesticide active ingredients was modeled. In most cases individual pesticide production data were not available. In such cases, the generic pesticide process “pesticide unspecified, at regional storehouse” from ecoinvent was used. Field emissions of pesticides are often farm-specific and models like in Birkved and Hauschild (2006) and Rosenbaum et al. (2008) can be used to estimate such emissions accurately.

3.2.7 FARM MACHINERY USE

Farm machinery use facilitates field work. The ecoinvent data set “fertilizing by broadcaster” with middle intensive fuel consumption was used as a proxy for horticultural machinery. Data on the number of machinery operations and the working hours for running the machines were used to quantify the amount of machinery input per kg of crop (Appendix B, Section 9.1.8).

3.2.8 ELECTRICITY USE IN GREENHOUSES

Greenhouse production implies electricity use, for example, for lighting and irrigation pumps. The electricity demand was estimated using information from Swiss cost calculation sheets (Arbeitsgruppe Betriebswirtschaft VSGP, 2005) assuming a price of 0.15 CHF/kWh for industrial companies. The average European electricity mix (ENTSO-E, former UCTE) of low voltage was used for all crops except those originating from the Americas, to which the U.S.-mix was applied.

3.2.9 HEATING OIL USE IN GREENHOUSES

Vegetables need to grow at specific temperatures. To be independent from outdoor temperature, greenhouses are built to provide the appropriate climate. To show the variability of fuel consumption related to seasonality, a time-dependent heating energy model for greenhouse production was developed and applied. This model considers the type of greenhouse (heat transmission properties), the building dimensions, the difference in outside and inside temperature required by the specific crop, solar irradiation and the yield. For details see the model documentation in the Appendix B, Section 9.1.9. If the sourcing season was unknown, an annual average amount (Arbeitsgruppe Betriebswirtschaft VSGP, 2005) of heating oil (fossil fuel) per crop was used for one growing period. All productions in Switzerland and further North were modeled as heated and nonheated to approximate a winter and a summer production respectively. All productions South of Switzerland were assumed to be nonheated.

3.2.10 IRRIGATION

Irrigation is needed in regions where rainfall is less than the amount of water required to grow a specific crop, where rainfall is seasonally unevenly distributed or if crops are cultivated in greenhouses. The amount of water irrigated depends on the culture as well as on soil and different climate parameters like temperature, wind and rainfall. The different amounts of irrigation water for all the crops grown in Switzerland are available from elsewhere (Arbeitsgruppe Betriebswirtschaft VSGP, 2005). Short-term crops (like lettuce and radish) and open field crops use 400–800 m^3/ha/growing cycle, long-term greenhouse crops use 3000–6000 m^3/ha/growing cycle (Arbeitsgruppe Betriebswirtschaft VSGP, 2005). The irrigation inventory for imported crops was calculated according to Pfister et al. (2011). As only the country of origin was known, a production weighted average amount was used, taking into account the geographical distribution of each crop within a country.

3.2.11 TRANSPORTATION

Domestic production covers 40% and 49% of the fruit and vegetable consumption respectively (Erdin et al., 2009), whereas the rest is imported. Imported products have to be transported to and distributed within Switzerland. Distribution is also required for domestic production. The most important production sites in a country were identified for each product and the most evident transportation routes and means were chosen according to the scheme in Table B.4 (Appendix B, Section 9.1.11). It was assumed that trucks from industrial countries are EURO 4 or 5 standard with cargo weight >32 t, except for distribution in Switzerland, which was modeled with a specific fleet average truck of >28 t. Truck-transportation in emerging economies was simulated with an EURO 3 standard for cargo weight >32 t. By sea route the products are transported by freight ship and in the air by an intercontinental freight aircraft. The corresponding ecoinvent processes were employed and distances were measured with online tools (Appendix B, Section 9.1.11).

3.2.12 COOLING DURING TRANSPORTATION

Crops need to be cooled in order to avoid decay before arriving at the point of sale and to elongate the storage life. Transportation was assumed to take place in fully loaded ISO-containers with independent cooling aggregates. According to Wild (2008b) the average power consumption of a container is 3.6 kW/h·TEU. One TEU (= twenty-foot equivalent unit) is the size of a little standardized container with an average load of 10 t (Wild, 2008a). Furthermore, the transportation time (Appendix B, Section 9.1.12) was needed to model the consumed cooling energy with the ecoinvent data set “diesel electric generating set”.

3.2.13 WASHING WATER

Several crops (asparagus, bananas, carrots, celery root, cucumbers, iceberg lettuce, lettuce, radish, spinach, and zucchini) need to be cleaned after harvesting. It was assumed that 0.4 L of tap water is used per kg of crop, except for bananas, which use 4.4 L per kg (Hernandez et al., 2000).

3.2.14 ELECTRICITY USE FOR STORAGE

Agricultural goods are stored in refrigerated units. Energy consumption depends on storage time, outside temperature, ideal storage temperature (crop specific) ranging from −2 to 13 °C (George and Eghbal, 2003; Hornischer et al., 2005; Konrad and Knapp, 2011; Konrad and Willging, 2011; Lichtenhahn et al., 2003; Wonneberger et al., 2004) and packing density, which is generally assumed to be 300 kg/m^3 (Wild, 2008a). Information on energy consumption was extrapolated from elsewhere (Blanke and Burdick, 2005a).

3.2.15 FERTILIZER EMISSIONS

Nitrate and phosphorus-emissions into different compartments were modeled generically, because no site-specific values of the productions sites (slope, soil, machine type, weather etc.) were available. On average, 6% of ammonium nitrate fertilizer is emitted into the air as ammonia (NH_3), 1.7% as nitric oxide (NO) and the same amount as nitrous oxide (N_2O) into the air as well, whereas 35% is estimated to be leached as nitrate (NO_3) into the soil (Richner et al., 2006). Constant values of phosphate emission into groundwater (0.07 kg phosphate/ha/a) and of phosphorus emission into surface water (0.245 kg phosphorus/ha/a) were assumed (Prasuhn, 2006).

3.2.16 OTHER PROCESSES

Assumptions and data about mulch film application and flame treatment are documented in the Appendix B, Section 9.1.6 and 9.1.7.

3.2.17 LIFE CYCLE IMPACT ASSESSMENT

The elaborated LCI data can be coupled with any LCIA method. In this paper, we show selected results for the impact categories climate change (Solomon et al., 2007) and water stress (Pfister et al., 2009). Results in terms of a LCIA method using multiple impact categories were calculated with ReCiPe (ReCiPe, 2010) and are shown in the Appendix B, Section 9.1.14. Human toxicity impacts due to pesticide use, if applied properly, were shown to be relatively small in relation to “other” impacts like GWP (Juraske et al., 2009) and were excluded in this study.

3.2.18 PRIORITIZATION OF CROPS

In order to efficiently identify improvement potentials, crops were first ranked according to the impact caused by the total sales volume of a crop ($IS_{c,total}$ in Eq. 3.1):

$$IS_{c,total} = \sum_i \sum_j m_{c,i,j} \times is_{c,i,j} \quad \text{(Eq. 3.1)}$$

where $is_{c,i,j}$ is the specific impact score per kg of crop *c* from origin *i* and produced with mode of production/transportation *j*, and $m_{c,i,j}$ is the respective mass of crop *c* sold by the retailer.

In addition to the total impact, the sales-amount weighted average impact per kg of product and the variation in specific impact across different origins, production techniques and mode of transportation were also taken into consideration. Priority crops for an in-depth investigation were selected by quantifying the maximal (not necessarily realistic) improvement potential per crop according to Eq. 3.2:

$$I_c = \frac{m_{c,total} \times (is_{c,average} - is_{c,min})}{IS_{c,total}} \quad \text{(Eq. 3.2)}$$

where I_c is the maximal improvement potential for crop *c* (in % of total current impact), $m_{c,\text{total}}$ is the total mass of crop *c* sold, $is_{c,\text{average}}$ is the sales-amount weighted impact score per kg of crop c and $is_{c,\text{min}}$ the minimal specific impact for crop c found in the considered origins and mode of production/transportation. Those crops for which the sum of the improvement potentials was larger than one-third of the current CO_2-footprint (Finkbeiner, 2009) were selected for in-depth analysis.

3.3 RESULTS

3.3.1 CARBON FOOTPRINT

Figure 3.2 shows the CO_2-footprint of fruit and vegetable sales, calculated according to Eq. 3.1 (Figure 3.2a) and the specific CO_2-footprint with its variation (Figure 3.2b).

Asparagus, lettuce and cucumbers were selected for in depth investigation, to derive high-leverage recommendations for a reduction in environmental impact. Switching to the respective production alternative with minimal impact for these three crops would achieve a reduction of more than one-third of the current overall CO_2-footprint caused by the sale of all crops considered (Table 3.1). Tomato also exhibits a relatively high improvement potential.

Other crops like bananas, pears, apples, citrus fruits, and potatoes also cause a relatively large total CO_2-footprint because of large amounts sold, but due to their small specific impact the potential for improvement is limited.

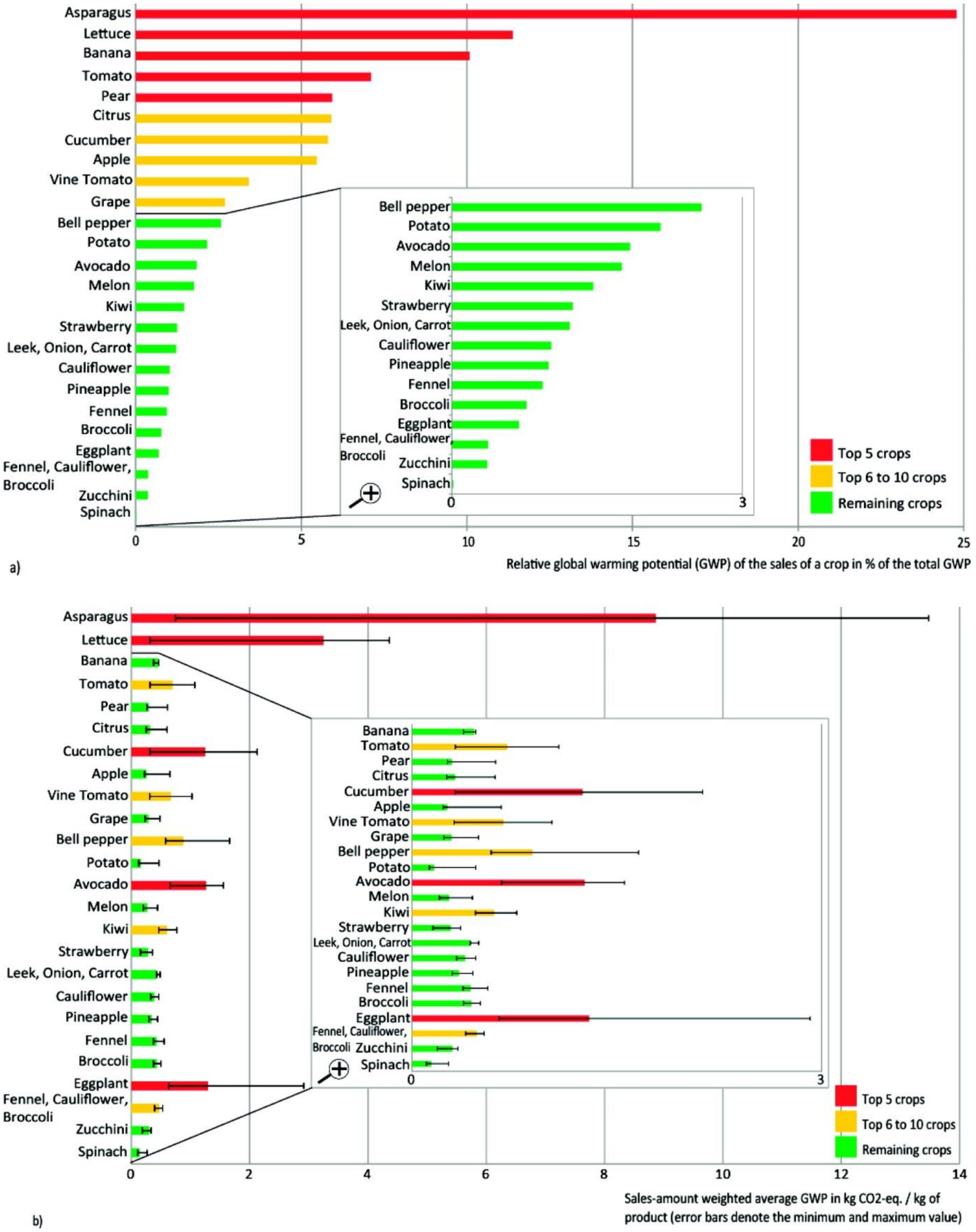


Figure 3.2 Relative global warming potential (GWP) in % of the total GWP generated by all considered fruits and vegetables sold in 2007 (ordered from top to bottom, 2a) and sales-amount weighted impact per kg of product (2b). The error bars denote the minimum and maximum specific impact over all options assessed (varying origin, means of transportation, production modes, etc.).

Table 3.1 Theoretical Improvement Potential in % of Current Overall CO_2-footprint (Only Crops >1% Displayed), Calculated According to Eq. 3.2

	theoretical improvement potential (%)
asparagus	22.7
lettuce	10.3
cucumber	4.3
tomato	3.9
vine tomato	1.8
banana	1.7
citrus	1.2

Asparagus was clearly the most important crop to be analyzed according to the ranking scheme applied. Figure 3.3 shows that the main load of the GWP originates from air transport from Mexico and Peru. The carbon footprint of different origins and transportation options differs by a factor of 16–19, respectively, from the lowest (produced locally in Switzerland) to the highest (imported by airplane from Mexico (green asparagus) and Peru (white asparagus)). Therefore, a recommendation to reduce air transport and to encourage seasonal production from near regions was derived.

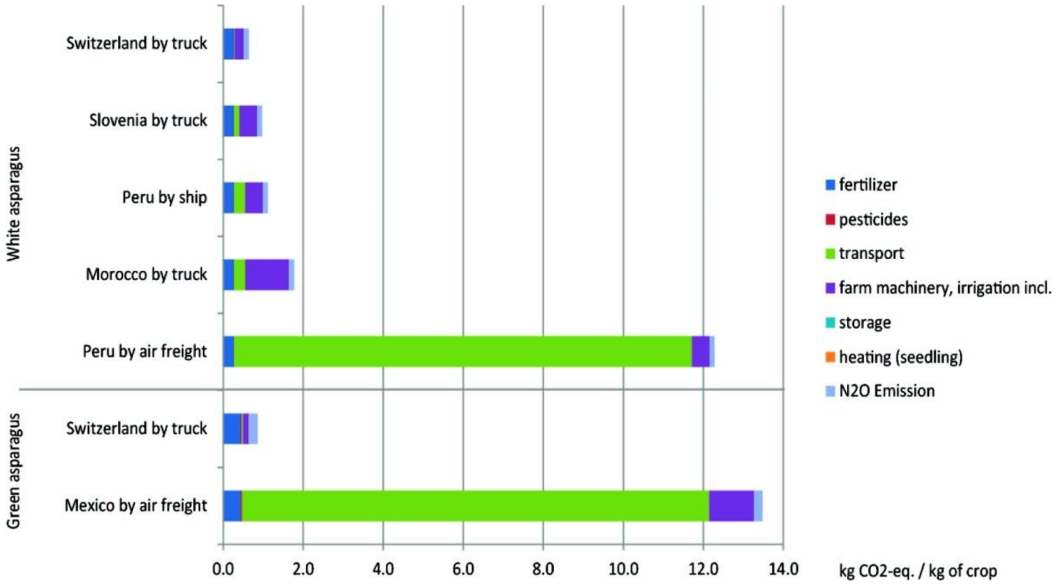
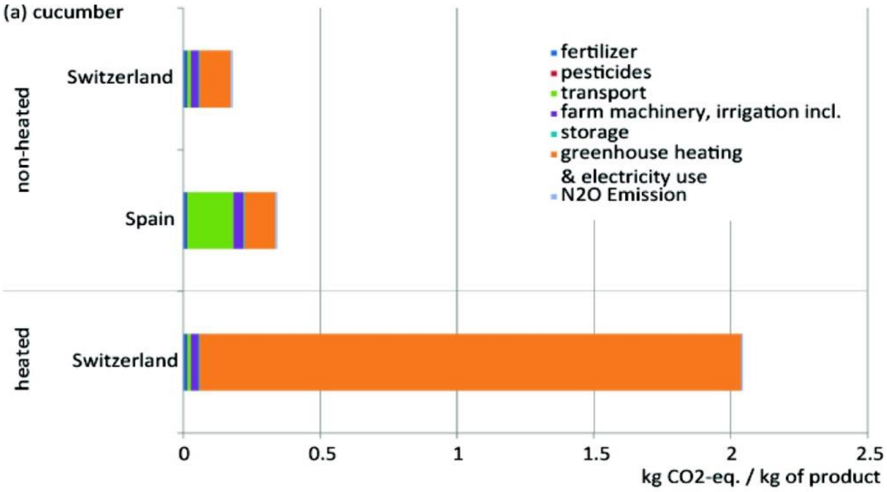


Figure 3.3 GWP of green and white asparagus imported to Switzerland from different countries of origin.

For the remaining crops, classified as "high priority to reduce the carbon footprint", the main driver of impact was greenhouse heating with fossil fuels during production out of season. For example, a comparison between Swiss cucumber production from unheated and heated greenhouses shows a GWP-difference by a factor of more than 10 (Figure 3.4). A large difference between heated and nonheated production can also be observed for eggplants (factor of 6), tomatoes and peppers (both factor of 4) and lettuce (factor of 10). Emissions including those from fossil fuel-heating are not evenly distributed over the whole season. The results of the GWP combined with the seasonal heating energy model are shown for a Swiss lettuce production in Figure 3.4.

(a) cucumber



(b) lettuce

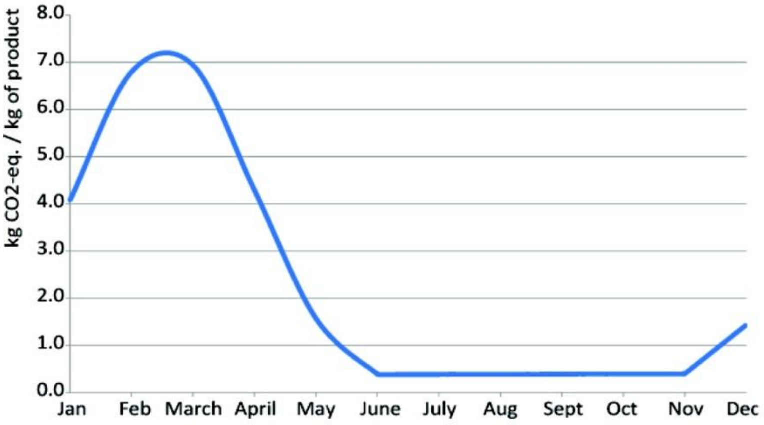


Figure 3.4 GWP of cucumbers grown either unheated or in (with an annual average amount of heating oil) fossil fuel heated greenhouses (a). GWP of lettuce at harvesting time produced in a greenhouse for a year-round production (b).

Energy demand for cool storage induces less GWP than import by ship from Southern countries. For example comparing kiwis imported from Italy and New Zealand, import from Italy is always less CO_2-eq. intensive, even when considering 36% higher yields, which have been reported for New Zealand (FAOSTAT, 2008).

Different scenarios of the total GWP of the fruits and vegetables assessed reveal a reduction potential of 42% changing from the scenario with air-freighted oversea-asparagus and vegetables produced in heated greenhouses in Northern Europe to a supply without air transport and fossil fuel heated greenhouse productions. Without air transport, asparagus alone bears a GWP-reduction potential of 20%. A similar reduction (22%) can potentially be achieved by avoiding vegetables from heated greenhouses and sourcing them from Southern countries during winter and spring, or, even better, from heated greenhouses with waste heat from other industrial processes.

3.3.2 IMPACTS FROM WATER CONSUMPTION

In Figure 3.5b, the water consumed during the production of selected fruits of different origins is weighted by the water stress index (WSI)(Pfister et al., 2009). Differences in the environmental impact are mostly caused by water scarcity of a specific region and the ratio of irrigated water consumed to the yield. The impact is clearly visible for the asparagus and avocado production (Figure 3.5b), whereas for the other fruits and vegetables it is not. In some cases, a “good water performance” can be in contradiction to a “good GWP performance”, as in the case of citrus fruits from Israel (Appendix B, Section 9.1.15). In other cases, both indicators are in accordance, such as in the case of seasonal production of fruits and vegetables from Switzerland, which have a low impact with respect to both indicators.

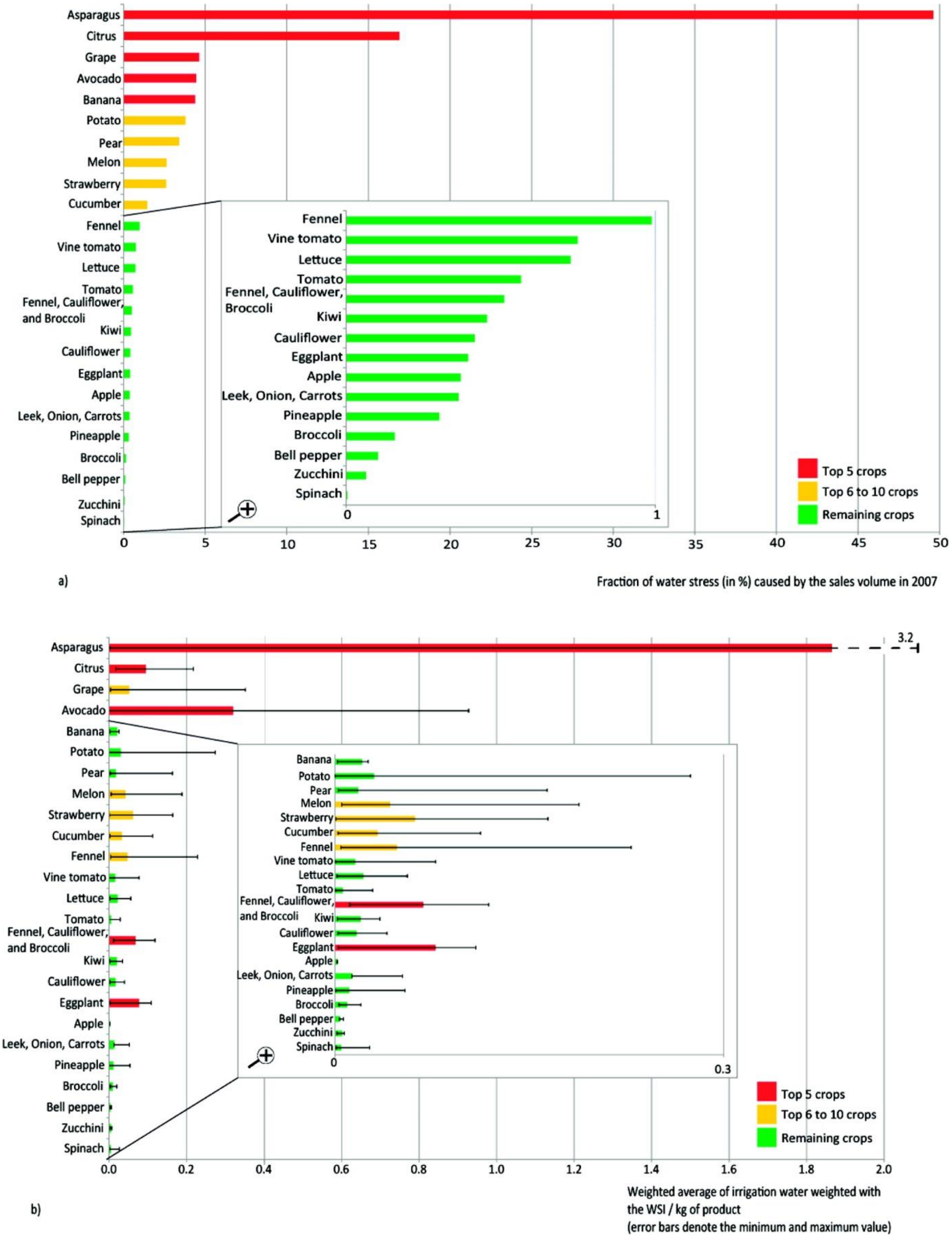


Figure 3.5 Fraction of water stress (in % and ordered from top to bottom) caused by the sales volume in 2007 normalized by the sum of water stress of all crops (5a) and sales-amount weighted water stress (irrigation water (m^3)·WSI) per kg of product (5b).

3.3.3 IMPLEMENTED MEASURES BY THE COMMISSIONER OF THIS STUDY

Several measures have been implemented to reduce the large impact due to air transport. Products transported by air freight are declared with a label “by air” and the emissions are fully compensated through offsetting schemes. Through efficient logistics and improved storage techniques the amount of white asparagus transported from overseas by ship was increased from 50−90% from 2007 to 2009. However, green asparagus is still not transported by ship from overseas due to substantial losses. To lower the impact of the green asparagus imported by air-freight the retailer decided not to sell this product at discount prices anymore since spring 2009. With this measure it was possible to reduce the emissions from air-transported asparagus by 75% from 2008 to 2009. In addition, a new production site in Taroudant, Morocco is being established to avoid air transport dependency (Coop Group, 2011). Furthermore, the results of the study were communicated to the purchasing staff (in the forms of a report, a leaflet and a calculation tool) to enable an environmentally informed supply chain management for all products.

3.4 DISCUSSION

3.4.1 RECOMMENDATIONS FOR DECISION MAKING

Airplane transport dominated the carbon footprint of fruits and vegetables, that is, asparagus and papaya. A decision recommendation for consumers could be, for instance, that seasonal consumption of local foods is to be preferred over out-of-season fruits and vegetables that are imported by plane. For retailers it is recommended to avoid long-distance transports or to prefer transport by ship whenever possible. These results are in accordance with the studies of Jungbluth et al. (2000) or Sim et al. (2007), but differ from Weber and Matthews (2008) who conclude that foodmiles in the U.S. are, on the whole, less relevant than agricultural production.

Another general result is that greenhouse heating may be a key process for vegetables that are grown out of season in colder climates. In many cases, heating greenhouses with fossil fuels was more important than ground transport, even if distances were long (e.g., South Spain to Switzerland). Thus, during winter and spring it is often better to purchase vegetables that are grown in greenhouses from Southern countries, where no heating is needed, while during summer or fall, local production is often better than imports. However, there is often a trade-off between the relatively low carbon footprint of winter and spring production in Southern countries and the water stress induced in these countries, a situation that needs to be carefully assessed case by case. The use of heating systems with nonfossil energy and particularly waste heat could be a solution which may reduce both carbon footprint and water stress impacts. Some greenhouses functioning with waste heat are already in operation, for example, the greenhouse attached to a municipal solid waste incineration in Hinwil (Marton et al., 2010), and the tropical centers in Frutigen and Wolhusen, Switzerland (Tropenhaus Frutigen AG and Tropenhaus Wolhusen AG, 2011), which are heated with geothermal heat (warm water effluent from a tunnel) and waste heat from a gas concentration unit respectively. The decision recommendation for food producers would thus be to search for such alternative heat energy sources or to avoid heating as much as possible. The latter is already standard practice for organic producers in Switzerland, as heating is only permitted to avoid harvest losses from freezing temperatures according to the standards of Bio Suisse (2011).

Retailers in Northern countries can lower the CO_2-eq. emissions by sourcing their greenhouse-grown products locally during the season. In winter and spring they should look for imports from warmer locations, provided that there are no adverse effects such as water stress (and further impacts not investigated here). Retailers are suggested to use results from LCA studies, to decide where to source each fruit and vegetable from, and which aspects to improve in collaboration with the producers in each case. They could also label best-practice products, although the communication of LCA-results to consumers is a challenging task and consumer organizations already warn against too much and too complex information on products (Doublet and Jungbluth, 2010; Golder et al., 2010). Finally, consumers should buy seasonal products or local products that can be stored over the season as much as possible to avoid both long-distance and air transport, as well as greenhouse heating. Moreover, it is desirable that crops with low specific impact are consumed in large amounts, as is already the case for pear, grape, potato, melon, carrot, etc. To enable such decisions, policy makers should ensure that retailers label the origin, transportation, and mode of production of their products.

Storage energy is in some cases significant, and efficient cooling technologies are fairly important. Nevertheless, local production combined with long storage tends to perform better than long-distance imports from countries like New Zealand, which is for certain crops, such as kiwi and apple, a relevant country for imports into Switzerland. Our results are in accordance with Blanke and Burdick (2005b) but in contradiction with Milà i Canals et al. (2007) who considered 5–40% loss for apples which are stored for 4–10 months. The latter assumption is justified for apples consumed in European spring.

In many purchasing decisions, retailers or consumers can generate significant savings in environmental impacts by following simple guidelines as outlined above. Although the study has been made for a Swiss retailer, the LCI data are adaptable to assortments of other retailers worldwide.

3.4.2 DATA UNCERTAINTY

Some key pieces of information about the supply chain like crop, origin, transportation mode, and sales numbers were provided by the retailer. The inventory data are based on this information and use generic data for the production processes, for example, Swiss averages from the horticultural association, which produces according to GAP. However, it should be noted that variability is large between regions and even between farms (Liu et al., 2010; Milà i Canals et al., 2006). For example, eutrophying emissions are a function of many parameters including climatic factors. Thus, our average data is rather uncertain and may need to be revised particularly for countries without GAP-tradition in the field of fertilization, yield and machinery use and in case the data is applied to retailers which do not make sure that GAP is followed by all suppliers. One possibility of how to do that is proposed by Roches et al. (2010). Similar adaptations may be used for a comparison between farms.

The storage lives of the analyzed products vary from 10 days to half a year, something which has, among other factors, an influence on the amount of food losses. Food losses may be significant (Gustavsson et al., 2011) and should be assessed, although we were not able to collect representative data within this study. Data on food losses are specific for each retailer, supply chain and crop. Thus, such data should be added to the inventory data when performing LCA studies.

3.4.3 IMPLEMENTATION ILLUSTRATED FOR THE CASE OF A SPECIFIC RETAILER

In the particular case of the commissioner of this study, it was decided that the highest leverage decisions can be taken on the levels of purchasing decisions of the retailers and communication to producers. The rational was that only sustainable products should be offered (also for social standards which are not discussed in this paper), so that the consumers can buy any product without violating minimum standards and the vast majority of customers is covered. Additionally, consumer information such as origin and mode of production of all fruits and vegetables are provided so that environmentally educated consumers have the chance to choose the environmentally friendliest product among those offered.

The results of the implemented measures shows that the reduction potential identified by a LCA-analysis and implemented into daily business can lower the overall impact without substantially compromising the company economically. It also demonstrates the opportunities of retailers for reducing environmental impacts of food consumption.

3.5 OUTLOOK

Food products are known to have significant environmental impacts other than climate change and water use impacts. Those other potential impacts should be covered in a LCA complementing the carbon and water evaluation to avoid problem shifting. Further environmental effects of concern include impacts from land use, eutrophication and toxic effects. While for some of these impacts (e.g., ecotoxicity and eutrophication) standard assessment methods exist, methodological developments are needed for others (e.g., soil fertility, erosion, salinization, and biodiversity impacts (Curran et al., 2011)). A complete LCIA including these impact categories is also needed for a fair comparison between organic and intensive production systems.

Furthermore, the assessment could be expanded to an analysis from cradle to grave, including the use phase (transport from the store to where it is consumed, preparation like e.g. cooking, etc.) and especially the food losses over the whole chain.

3.6 ACKNOWLEDGMENT

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CHAPTER 4

CLOSING DATA GAPS FOR LCA OF FOOD PRODUCTS: ESTIMATING THE ENERGY DEMAND OF FOOD PROCESSING

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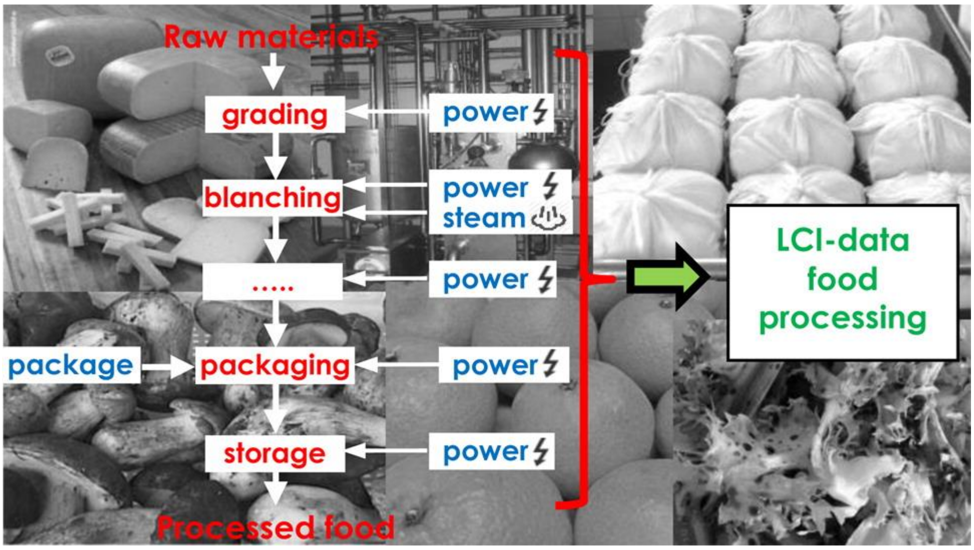

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The individual contribution of Franziska Stoessel consisted of collecting and preparing part of the data and their analyses and reviewing the manuscript for publication.

ABSTRACT

Food is one of the most energy and CO_2-intensive consumer goods. While environmental data on primary agricultural products are increasingly becoming available, there are large data gaps concerning food processing. Bridging these gaps is important; for example, the food industry can use such data to optimize processes from an environmental perspective, and retailers may use this information for purchasing decisions. Producers and retailers can then market sustainable products and deliver the information demanded by governments and consumers. Finally, consumers are increasingly interested in the environmental information of foods in order to lower their consumption impacts. This study provides estimation tools for the energy demand of a representative set of food process unit operations such as dehydration, evaporation, or pasteurization. These operations are used to manufacture a variety of foods and can be combined, according to the product recipe, to quantify the heat and electricity demand during processing. In combination with inventory data on the production of the primary ingredients, this toolbox will be a basis to perform Life Cycle Assessment studies of a large number of processed food products and to provide decision support to the stakeholders. Furthermore, a case study is performed to illustrate the application of the tools.

4.1 INTRODUCTION

The food sector, including agriculture, accounts for 20–35% (depending on the source) of worldwide total energy consumption along its whole life cycle (Tukker and Jansen 2006, Hertwich and Peters 2009). While a large share of impact comes from agricultural production, the food processing stage also makes up a sizable portion of the energy demand (Ramirez 2005). The large amount of food produced and consumed combined with the fact that its production requires electricity and thermal energy, mostly produced from fossil fuels, makes food manufacturing a relevant environmental issue. Thus, and taking into account the increasing pressure from both consumers and governments, it is essential to evaluate the impact linked to the energy consumption in food production.

To quantify the environmental impacts arising from food production, environmental assessment tools such as Life Cycle Assessment (LCA) should be applied. Most of the published LCA's on food are assessing primary agricultural products, e.g., Torrellas, Anton et al. (2012) and Stoessel, Juraske et al. (2012), whereas the number of studies available on processed food is lower, e.g., Berlin (2002), Hospido, Moreira et al. (2003) or Nilsson, Flysjo et al. (2010). Furthermore, these studies mostly consider the whole industrial process as a "black box", without taking into account the unit operations, that is, the steps that constitute the process. This is critical from a scientific point of view because of lack of transparency and reproducibility. In addition, such aggregated data does not allow for performing LCA studies on similar products, as the contribution of each process step to the overall LCA is not known. The large data gaps impede the implementation of carbon footprinting and other environmental labels as tools to diminish the environmental impact of food production. For instance, a new regulation in France (Cros, Fourdrin et al. 2010) originally foresaw that all food products were to carry a life-cycle based environmental label from January 2011 on, but the final version of the bill included a one-year experimental phase of energy-carbon labels (July 2011 to June 2012). Data gaps were one reason for the postponement. Filling these data gaps is not only useful for labels and hence for supporting decisions on product choices but also for identifying the most relevant stages and revealing improvement potentials within the value chain of foods. The latter is interesting for all actors involved in food production and consumption, i.e., farmers, food processors, retailers, and consumers.

The number of food products and processing stages is high. Food processes can be divided into common operations called unit operations. Examples of unit operations include blanching, dehydration, evaporation, or mixing, among others. These unit operations are used in the manufacturing of a variety of food products. Thus, energy inventory data of unit operations can facilitate to carry out LCAs of food processing. This data set can also be useful to design more environmentally friendly processes, since a proper selection and combination of unit operations allows for determination of the market forms that consume less energy. Similar studies have been performed in chemical processes to model and reduce the energy demand of unit operations in chemical batch production (Bieler, Fischer et al. 2003, Szijjarto, Papadokonstantakis et al. 2008).

The aim of this paper is to provide estimation tools for the energy demand of a range of food process unit operations. Together with data on the agricultural production of the primary ingredients, this toolbox shall be a basis to perform LCA studies of processed food and thus provide decision support for process optimization and product selection to the food processing industry, retailers, and consumers.

4.2 METHODS

4.2.1 GENERAL APPROACH AND DATA SOURCES

To avoid the “black box” information when computing the energy demand of food processing, a bottom up approach has been chosen, beginning from unit operations. In this way, it is possible to estimate the energy use of a wide range of food products since unit operations are common to different processes. The following unit operations are included in this paper: (1) blanching and cooking; (2) evaporation; (3) dehydration; (4) precooling; (5) freezing; (6) refrigeration and frozen storage; (7) pasteurization; (8) frying; (9) baking and roasting, and (10) operations using a motor.

To calculate the energy consumption of food processing, two kinds of information modules are needed (Figure 4.1). The input data module corresponds to the data to estimate the energy consumption. First, the recipe of the product is needed, that is, information about the raw materials and a description of the unit operations and apparatuses used, including parameters such as temperature or time. The term “apparatuses” means the technological options for a specific unit operation. Since in some cases several technologies are presented to perform the same operation, the LCA practitioner can choose among them, and the specifications of the apparatuses (e.g., power, flow, and engine efficiency) must be collected. Next, data about the physicochemical properties of the raw material are necessary to estimate the energy demand in those unit operations related to heat transfer. Specifically, heat capacity, thermal conductivity, thermal diffusivity, and density are key properties. Water activity is another important property when designing dehydration processes. Data about these properties can be found in the literature (Lewis 1990, Saravacos and Maroulis 2001, Rahman 2009). Table 10.1 in the Appendix C provides an overview of these properties for some example products. When these data are not available, they can be calculated by using correlations, such as those presented in the Appendix C.

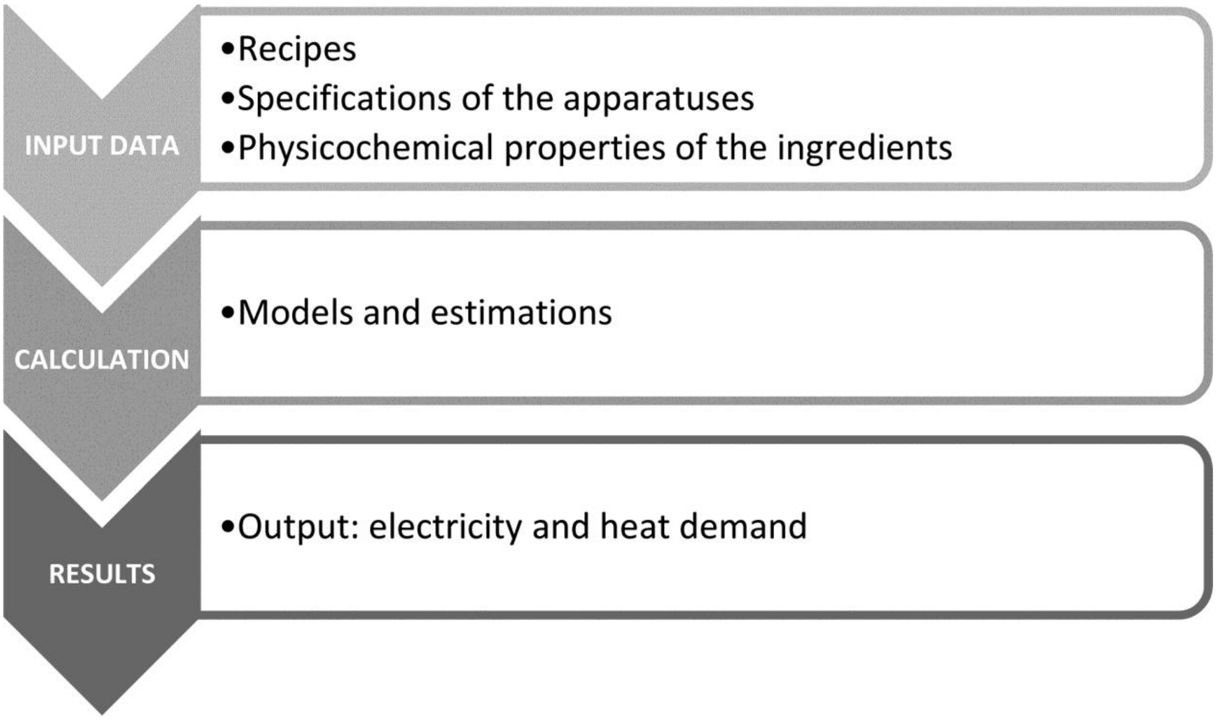

Figure 4.1 Procedure and data input for estimating energy demand of food processing to calculate energy consumption in food processing.

The calculation module consists of the models and estimation procedures to quantify the energy consumption of the process, based on process models and physical or empirical relationships. For each unit operation, both the electricity and thermal energy consumption are estimated. These data must be connected with the respective background inventories for the electricity mix or steam production to complete the LCA study (e.g., from databases such as ecoinvent). The focus was placed on energy consumption as it has been shown to be a key inventory flow of food processing in previous studies (Berlin 2002, Hospido, Moreira et al. 2003). Other inventory flows, such as water, should be added in the future, e.g., with estimation tools similar to the ones presented here. Some data from published literature on energy consumption of unit operations are also shown in Tables 10.3 and Section 10.4 in the Appendix C.

4.2.2 ESTIMATING THE ENERGY DEMAND OF UNIT PROCESSES

In the following, we describe the models and estimation procedures for each unit process. For each, the same format will be followed: first, a short description of the unit operation and equipment is provided; then, some theoretical calculations and literature values for the energy demand are presented; finally, when more than one approach is proposed, recommendations for the choice of approach for estimating the energy demand are provided.

4.2.3 BLANCHING / COOKING

Blanching implies exposing a vegetable to a heat source, generally steam or hot water, during a predetermined time at a specified temperature. It is a pretreatment applied before some preservation operations (e.g., sterilization, dehydration, and freezing). Its main purpose is to achieve storage stability in cases where the enzyme activity continues even under refrigerated or frozen storage conditions or in dehydrated foods (Heldman and Hartel 1998).

Cooking is the process of preparing a food with heat. It aims to change a food's characteristics to make it more attractive and digestible, favoring its conservation. Although there are many cooking methods (e.g., steam, water, oil, and vacuum), we will refer to steam or water cooking, which is performed in industry using the same blanching equipment.

Commercial blanching equipment involves passing the food through an atmosphere of saturated steam or a bath/shower of hot water. Generally, leaching losses are much smaller in steam blanchers (Fellows 2000). At its simplest, a steam blancher consists of a mesh conveyor belt that carries food through a steam atmosphere in a tunnel (blancher with no end seals in Table 10.3, Appendix C). Thus the energy consumption of a conveyor blancher comprises thermal energy consumption (steam or water) and power consumption for the belt and other mechanical devices. The thermal energy (Q_B, kW) needed for blanching is (Eq 4.1):

$$Q_B = F_{C_F}(T_B - T_F) + Q_L \text{ (4.1)}$$

where F (kg/s) is the flow of food to be blanched; c_F is the specific heat of the food (kJ/kg °C); T_F and T_B are the initial-food and blanching temperatures (°C), respectively; and Q_L is the heat loss from the blancher. Heat losses comprise those by radiation and convection from the blancher surface but also other losses that depend on the equipment design, such as escape of steam and loss due to evaporation from water surfaces. A mathematical description of the radiation and convection terms is given in the Appendix C (Eqs 10.12 and 10.13).

In Table 10.3 (Appendix C), the thermal energy consumption of steam and water blanchers from literature is provided. Lung, Masanet et al. (2006) measured the specific energy consumption, and it was between 0.88 and 1.88 MJ/kg product. These authors estimate energy savings from 30% to 70% for modern blanchers compared to traditional ones.

To summarize, since loss terms can be very high and difficult to quantify without precise knowledge of the blanching equipment (Scott, Carroad et al. 1981), the use of empirical values for calculating the consumption of thermal energy is recommended. Electricity needs are low compared with thermal energy consumption (see Table 10.3 in the Appendix C) and can be approximated as 1.1–2% of the thermal energy (Scott, Carroad et al. 1981, Rumsey, Scott et al. 1982, Lung, Masanet et al. 2006).

4.2.4 EVAPORATION

Evaporation is one of the most used technologies for liquid concentration. It involves water removal by boiling, with a concentrate stream remaining after separation of the generated vapors (Heldman and Hartel 1998). Typical applications of evaporation are concentration of fruit juices and dairy products. It is also a preparation step for dehydration (e.g., milk powder).

An evaporator may be designed as a single-effect system (Figure 10.1 in the Appendix C) or as several evaporator bodies connected as a multiple-effect system (Figure 10.2 in the Appendix C). Multiple effect evaporators use the vapors produced in one evaporation stage as an energy source in the next effect. The first effect of a multiple-effect evaporator is the effect to which the fresh steam is fed and in which the vapor pressure is the highest. Thermally accelerated short time evaporators (TASTE) are widely used because they provide maximum energy saving (5 to 8 effects) while preserving the organoleptic characteristics of the product (Filho, Vitali et al. 1984) with concentration time lower than 2–3 min. It is also possible to reuse the vapors produced during evaporation by using recompression processes. In thermocompression evaporators (TVR), fresh steam is mixed with the vapors. A mechanical recompression evaporator (MVR) using a steam compressor is also possible.

The steam (heat requirement) needed to concentrate a liquid food can be calculated from the mass and energy balances in the case of a single-effect evaporator (Eqs 10.14–10.16 in the Appendix C). In the case of a multiple-effect system, an iterative method is proposed in the Appendix C (Eqs 10.17–10.21).

Thermal energy requirement can also be calculated based on performance measures of evaporators. Performance indexes are steam economy (E) and its capacity (V). V is the amount of water evaporated per time unit; it depends on the operating temperature range and type of products handled. V can be calculated from the total mass and solute balances as

$$V = F\left(1 - \frac{x_f}{x_n}\right) \quad (4.2)$$

where F is the flow of feed to be concentrated (kg/s), x_f and x_n the mass fractions of solids in the feed and final concentrate streams.

E is the ratio of total water evaporated from the food to steam consumed. It is related to the number of effects (N) by a coefficient A

$$E = AN \quad (4.3)$$

A depends on the evaporator configuration, and variations of E are due to factors such as evaporator design, feed temperature, insulation, venting, or vacuum leakage. Once E and V are known, the steam consumption W (kg/s) can be calculated as

$$W = \frac{V}{E} \quad (4.4)$$

Values of A and E for different evaporators' configurations are presented in Table 10.5, Appendix C. These values together with Eq 4.4 allow for the calculation of the steam consumption in a simple way.

From the two methods proposed to estimate the heat requirement (*W*), the one based on the mass and energy balances (Eqs 10.14–10.16 and 10.17–10.21) is more accurate than the one based on the performance of the evaporator (Eq 4.2–4.4 and Table 10.5, Appendix C), inasmuch as reliable *A* values for all evaporators are not always available. Due to data limitations the latter approach may however often represent the only feasible option.

Electricity consumption is very low compared to heat requirement, e.g., for tomato concentration (Table 10.3, Appendix C) it amounts for only between 1.3 to 2.4% of total energy consumption. The electricity consumption of a TVC milk evaporator amounts to around 7% of total energy consumption (Westergaard 2004) (Table 10.4, Appendix C). The total installed power in a TASTE evaporator averages 5–6 kW/ton evaporated water, ranging from 5 to 10 kW/ton for smaller plants to 2–5 kW/ton for high-capacity models (JBT FoodTech 2012).

4.2.5 DEHYDRATION

Drying or dehydration is a unit operation to preserve foods as a result of the depression of water activity. Dehydration also aims to reduce the weight and volume of the product and to impart desirable features to food such as flavor or texture.

Water activity (a_w) describes how water interacts in foods. It is an important concept because the state in which the water is present affects the shelf life and the susceptibility to microbial and chemical spoilage reactions (Foods 2005). The values of a_w should be lower than 0.90, 0.85–0.88, and 0.80, to prevent spoilage through bacteria, yeasts, and molds, respectively (Smith 2003). a_w is often defined as the ratio of vapor pressure of water measured at the food surface to saturation vapor pressure of pure water at the same temperature. As a food dries, both moisture content and a_w change. The equilibrium moisture content is the moisture content at which the food is neither gaining nor losing moisture; this however, is a dynamic equilibrium and changes with relative humidity and temperature. The relationship between the equilibrium moisture content in the food and the relative humidity of air specifies the water content in a food that can be reached for any drying condition (Heldman and Hartel 1998). Sorption isotherms for many foods can be found in the literature (Iglesias and Chirife 1982), and they allow for the determination of the moisture content of a food that ensures a low enough a_w to obtain a stable product.

Numerous types of dryers are used in food industry (Table 10.6, Appendix C), and most of them use hot air for convective heat transfer. Application of mass and energy balances gives information on dryer performance (Eqs 10.22–10.25 in the Appendix C) (Baker 2003).

Energy balance (Eq 10.23) without heat losses provides the minimum energy for drying, but heat losses should be calculated. Losses can be significant and will depend on the type of dryer and operating conditions; for instance, the mean ratio of heat losses to heat input was found equal to 0.306 for single stage dryers, and 0.127 for multiple stage spray dryers (Marcotte and Grabowski 2008). Since it is not always possible to quantify all losses, the use of energy coefficients (Tables 10.7–10.9, Appendix C) is useful to calculate the actual energy consumption of dryers. The ones most used are the specific energy consumption, the efficiency of energy use, and the thermal efficiency (Kudra 2004, Marcotte and Grabowski 2008). The specific energy consumption is the energy consumed per unit mass of product (kJ/kg). The efficiency of energy use (η) is the proportion of the energy consumption that is used for the evaporation of water only

$$\eta = \frac{E_1}{E_2} = \frac{W\Delta H_v}{E_2} \quad (4.5)$$

where E_1 is the energy required for the moisture evaporation, E_2 is the total energy supplied to the dryer (e.g., from fossil fuel or electricity), W is the total amount of water transferred from the foodstuff to the air (Eq 10.12), and ΔH_v represents the heat of vaporization of water (2.443 kJ/kg). Thus once η, W, and ΔH_v are known, the total energy consumption, E_2, can be isolated from Eq 4.5.

The thermal efficiency (η_T), measured by air temperature profiles, is defined as

$$\eta_T = \frac{T_1 - T_2}{T_1 - T_0} \quad (4.6)$$

where T_1 and T_2 are the temperatures of the drying agent (generally air) at the dryer inlet and outlet, respectively, and T_0 is the ambient temperature. The difference (T_1 – T_2) reflects the stream of heat in the dryer not only for moisture evaporation, but also for dried material heating and heat losses. The difference (T_1 – T_0) reflects the stream of heat provided to the drying agent in the heater of the dryer. Therefore, if η_T, T_1, and T_2 and the flow of air G (kg dry air/s) are known, the heat provided to the drying agent can be calculated as

$$E_2 = G \times c_G \times (T_1 - T_2)/\eta_T \quad (4.7)$$

where c_G is the humid heat of the air (kJ/kg dry air °C) that depends on the absolute moisture content of the air (Y, kg water/kg dry air) $c_G = 1.005 + 1.88Y$.

Table 10.4 in the Appendix C shows the energy consumption for skim milk drying with several equipment configurations (Westergaard 2004).

Taking into account that heat losses of a dryer are not easy to quantify and that data about mean ratio of heat losses to heat input are scarce in the literature, we recommend, in the absence of better data, to use energy coefficients specific for the type of dryer (see Tables 10.7–10.9, Appendix C for values) to calculate the actual energy consumption (Eqs 10.5–10.7).

4.2.6 PRECOOLING

Precooling is the rapid removal of heat from freshly harvested fruits and vegetables before shipping, storage, or processing (Ashrae 2010). Prompt precooling inhibits growth of microorganisms, reduces enzymatic and respiratory activity, and reduces moisture loss. Precooling requires greater refrigeration capacity in comparison to that required for holding a product at a constant temperature or for slow cooling of a product (Brosnan and Sun 2001). Thus, precooling is typically a separate operation from refrigerated storage requiring specially designed equipment (Ashrae 2010).

The principal precooling methods are hydrocooling, forced air cooling, package icing, vacuum cooling, and cryogenic cooling. As for dryers, to calculate the energy consumption of precooling systems, the use of an efficiency coefficient (EC) is recommended. EC (kJ heat energy removed/kJ of electricity consumed) is calculated as the amount of cooling work accomplished divided by the amount of electricity purchased by the cooling facility (Thompson, Mejia et al. 2010):

$$EC = \frac{M \times c_p \, (T_i - T_f)}{E \times c} \quad (4.8)$$

where M is the mass of product cooled; c_p the specific heat of the product above freezing; T_i the initial temperature of product; T_f the final temperature of product; E the electricity consumed to operate the cooling facility; and c the conversion factor (3600 kJ/kWh); therefore, if EC, M, c_p, T_i, and T_f are known, the electricity consumption (E) can be isolated from Eq 4.8.

The EC of cooling systems are, on average (Thompson and Chen 1988, Thompson and Chen 1989), 1.8 (ranging between 1.4 and 2.4) for vacuum cooling, 1.4 (ranging from 0.7 to 2.2) in the case of hydrocoolers, 1.1 (ranging between 1 and 1.4) for water spray vacuums, and 0.4 (ranging between 0.12 and 0.71) for forced-air cooling.

Interestingly, the average EC for forced-air cooling reported by Thompson and Chen (1988) is the same as the one reported by Thompson, Mejia et al. (2010) indicating that EC has not significantly decreased in the last twenty years.

Variation between cooler types is explainable by the levels and types of heat input into them. Water spray vacuum coolers, hydrocoolers, and forced-air coolers have a number of heat inputs other than the product, while vacuum coolers remove heat only from the product (Thompson and Chen 1988).

4.2.7 FREEZING

Freezing is the preservation process in which the temperature of the product is reduced to levels below the temperature at which ice crystals begin to form within the food, limiting the growth of most microorganisms.

Differences between freezing equipment lie in the operating mode (batch or continuous) and in the freezing medium. Air-blast freezers are the most common. Plate freezers consist of a series of parallel plates through which a coolant is circulated. In cryogenic freezers, the product is either sprayed with or immersed in the cryogen (mainly liquid nitrogen or carbon dioxide) at atmospheric pressure.

The energy consumption, or total heat load (Q_tot), of a freezer consist of two main components, the energy needed to freeze the product (Q_pr) and the energy needed by the fans (or pumps for plate and immersion freezers), plus a number of smaller components: defrost, freezer pull-down, insulation ingress, air infiltration, and equipment other than fans or pumps (e.g., mechanical drives).

A key parameter to calculate the energy for freezing is the freezing time (t_f, s), that is, the total time required to lower the product temperature to a given final one at its center (Delgado and Sun 2001). Several t_f prediction methods have been proposed, and a simplified method for practical calculations is (Salvadori, Reynoso et al. 1987):

$$t_f = (A_1 T_c + B)(\frac{1}{B_i} + c)\left[(T_{if} - T_i)/T_{if}\right]^n \left[(T_f - T_{if})/T_{if}\right]^{-m} \alpha_0^{-1} R^2 \text{ (4.9)}$$

where A_1, B, c, m, and n are constants (Table 10.10, Appendix C); T_c is the temperature in the center of the product at the end of the freezing process (recommended −18 °C); T_i the initial temperature; T_f the cooling medium temperature; T_{if} the freezing temperature; α_0 the thermal diffusivity of fresh food (m^2/s); R the characteristic dimension of the product, defined as the shortest distance from the thermal center (slowest point to cool) of the product to the product surface; B_i the Biot number (Eq 4.10), a function of the conductivity of the unfrozen food (k, W/mK), the surface heat transfer coefficient (h, W/m^2K), and R:

$$B_i = \frac{hR}{k} \text{ (4.10)}$$

Q_{pr} is given by Berk (2009):

$$Q_{pr} = \frac{W_{pr}}{t_{pr}}\left[c_u\left(T_i - T_{if}\right) + L + c_f\left(T_{if} - T_{out}\right)\right] \text{ (4.11)}$$

For a continuous freezer, W_{pr} is the amount of product resident in the freezer at any time and t_{pr} is the product residence time (W_{pr}/t_{pr} equals the production rate). For a batch process, W_{pr} is the size of each batch and t_{pr} the cycle time for each batch of product ($t_{pr} > t_f$). T_{if} is the initial freezing temperature of the product; T_{out} the outlet mass-average temperature; c_u and c_f the unfrozen and frozen specific heat (J/kg K); and L the latent heat of freezing (J/kg). At the end of the freezing process, there will be a temperature gradient from the center to the surface of the product, and T_{out} will be between T_c and T_f.

Assuming a well-designed freezer, typical contributions of heat load components are given in Table 10.11, Appendix C. In this way, after calculating Q_{pr} (Eq 4.11), Q_{tot} and the rest of components can be estimated from the percentages shown in Table 10.11, Appendix C.

To calculate the energy use of the mechanical refrigeration system (Q_{refrig}) needed, it must be taken into account that the main energy users are the compressor and freezer fans, but ancillary equipment (e.g., pumps and control systems) is also important. Ancillary equipment (Q_{anci}) typically requires 15 to 20% of the compressor energy use. The relationship between heat load and compressor energy use is given by the coefficient of performance (COP; Eq 4.12). Typical COP for "good practice" industrial refrigeration systems can be found in the literature, e.g. in Cleland and Valentas (1997), and also in the technical specifications of compressors.

$$Q_{comp} = \frac{Q_{tot}}{COP} \text{ (4.12)}$$

4.2.8 REFRIGERATED / FROZEN STORAGE

Once the product is frozen or precooled, it is stored in chambers at the appropriate temperature during varying periods. The refrigeration requirement (or refrigeration load) of storage rooms comprises (Berk 2009): heat transfer through the insulation; air changes; introduction of goods at temperatures higher than that of the room; heat generated by respiration (fruits and vegetables); defrosting cycles; compensating for waste heat release of electrical devices such as evaporator fans, forklifts, conveyors or lighting; and people working in the room.

The equations to calculate the elements of the refrigeration load are shown in the Appendix C (Eqs 10.26–10.33). To calculate the electricity consumed by the refrigeration equipment, Eq 4.12 and the same assumptions as for freezing can be applied. Prakash and Singh (2008) compared predicted and actual power consumption in frozen warehouse and the differences amounted to only 11%. Thus, using theoretical thermal energy balance seems to be a good procedure for estimating actual energy consumption. These authors also report all thermal energy loads and electric loads in a warehouse (Table 10.12, Appendix C). This table can be a simple way to calculate the electric load of frozen and refrigerated storage, once the product heat load is known (Eq 10.30).

To satisfy the cooling requirements, a refrigeration cycle is needed (compressor, evaporator, condenser, and corresponding pumps and valves); to calculate the energy consumption of the compressor, Eq 4.12 can be used together with the recommendation of the previous section for ancillary equipment (15–20% of the compressor energy use).

Jiménez-González and Overcash (2000) give a detailed description of the inputs for Life Cycle Inventories of refrigeration cycles.

An alternative and simpler way to estimate the energy consumption is using empirical values. Based on expert judgments (Tefrile 2012), the following values of the refrigeration load are recommended: 10–12 W/m^3 day for a storage chamber at 0 °C and 35–40 W/m^3 day for a chamber at −18 °C. Moreover, the electricity needed in a refrigeration cycle using R507A (refrigerant fluid mostly used in small and medium size facilities) can be correlated with the refrigeration load attending to the refrigerant evaporation temperature as (Tefrile 2012):

1. For +2 °C evaporation temperature (working rooms): 0.33 kW electricity/kW refrigeration load
2. For −8 °C evaporation temperature (storage chamber): 0.41 kW electricity/kW refrigeration load
3. For −26 °C evaporation temperature (storage chamber for frozen products): 0.62 kW electricity/kW refrigeration load

Due to the uncertainties associated with these empirical values, we recommend to calculate the refrigeration load through Eqs 10.26–10.33 and 4.12, whenever the data needed is available. The use of empirical percentages as those shown in Table 10.12, Appendix C can also be useful, although they should be validated with data from more warehouses. Only otherwise the empirical values (see previous paragraph) should be used as a rough estimate.

4.2.9 PASTEURIZATION

Pasteurization is a mild thermal process applied to liquid foods to increase their shelf life during refrigeration and to ensure safety concerns associated with vegetative pathogens (Heldman and Hartel 1998). The temperature of the pasteurization process depends on the pH of the product; the higher the pH, the more severe is the thermal process. Table 10.13 in the Appendix C gives examples of pasteurization treatments.

In batch pasteurizers, the liquid is placed into a vessel heated with a steam or hot water jacket. However, large-scale pasteurization is usually carried out in continuous plate heat exchangers. In operation, food is pumped from a tank to a regeneration section, where it is preheated by food that has already been pasteurized. It is then heated to a pasteurizing temperature in a heating section and held for the time required to achieve pasteurization in a holding tube. The pasteurized product is then cooled in the regeneration section (and simultaneously preheats incoming food) and further cooled by cold water or a refrigerant fluid such as glycol. Nowadays, heat recovery percentages between 80 to 95% are achieved.

Taking into account that the percentage of recuperation of a heat exchanger is

$$heat\ recovery(\%) = \frac{T_2 - T_1}{T_3 - T_1} \times 100 \ (4.13)$$

where T_1 is the inlet temperature; T_2 the preheating temperature; and T_3 the pasteurization temperature.

The temperature increase can be computed as

$$\Delta T = T_3 - T_1 \ (4.14)$$

The heat recovered, provided by the fluid that is being cooled, is $\Delta T_R = \Delta T$ heat recovery/100

Thus, the heat to be provided by the heating system is

$$\Delta T_{needed} = \Delta T - \Delta T_R \ (4.15)$$

And the thermal energy needed is

$$Q = m_L \times \rho \times c_p \Delta T_{needed} \times t \ (4.16)$$

where Q is the thermal energy needed; m_L the volumetric flow of liquid; ρ the density of the liquid; c_p the specific heat; and t the pasteurization time.

4.2.10 FRYING

Frying is a cooking method where fat or oil is used as a heat transfer medium in direct contact with the food (Moreira 2001). The oil is heated at a temperature higher than the boiling point of water, and the food undergoes physical and chemical transformations.

Fryers can be batch or continuous. Continuous fryers contain an oil bath through which the product is conveyed on a mesh belt, and the oil is heated by combustion gases or by electric resistances (Berk 2009). Rywotycki (2003) developed a model to calculate the thermal power consumption during continuous frying of foods, assuming steady state. The amount of water removed from the product is

$$m = m_1 - (m_2 - m_3) + m_4 \ (4.17)$$

where m is the weight of water introduced in the fryer together with raw product (kg/s); m_1 the raw product weight (kg/s); m_2 the fried product weight (kg/s); m_3 the weight of fat absorbed by the food (kg/s); and m_4 the weight of water on the surface of the raw product after previous washing (kg/s).

For a fryer in steady state

$$Q_T = Q_1 + Q_2 + Q_3 + Q_4 + Q_5 + Q_6 \ (4.18)$$

where Q_T is the total thermal power (kJ/s) and $Q_{1 \ldots 6}$ are the partial thermal powers (kJ/s).

Q_1 is the thermal power for heating and evaporating water contained in the raw product

$$Q_1 = [c_1(T_2 - T_1) + r](m_1 - m_2 + m_3 + m_4) \ (4.19)$$

c_1 is the specific heat of water (kJ/kg °C); T_1 the temperature of the raw product (°C); T_2 the temperature of water boiling point (°C); and r the heat of water evaporation (kJ/kg).

Q_2 is the thermal power for heating the raw product

$$Q_2 = c_2(T_3 - T_1)(m_2 - m_3) \ (4.20)$$

c_2 is the specific heat of the raw product (kJ/kg °C) and T_3 is the frying fat temperature (°C).

Q_3 is the thermal power for heating the fat

$$Q_3 = c_3(T_3 - T_4)m_3 \ (4.21)$$

c_3 is the specific heat of the fat (kJ/kg °C) and T_4 is the temperature of fat placed in the fryer (°C).

Q_4 is the heat transmitted through the fryer casing to the environment

$$Q_4 = UA(T_6 - T_5) \ (4.22)$$

U is the overall heat transfer coefficient from the fryer casing to the air (kW/m^2 °C); T_5 the ambient temperature (°C); T_6 the temperature of the fryer casing (°C); and A the surface of the fryer casing (m^2).

Q_5 refers to the thermal energy losses transmitted by the fryer ventilation system to the environment and evaporated to the environment. On an average, these losses (Q_5) reach 10% (Rywotycki 2003).

4.2.11 BAKING / ROASTING

Baking is an operation located at the end of processing for the manufacture of a variety of starchy foods, which is carried out in an oven. Roasting is essentially the same, but in common language baking is usually applied to flour-based foods and roasting to meats, nuts, and vegetables (Fellows 2000). In this paper, baking includes both operations.

Industrial ovens for baking can be classified into four categories (Marcotte and Grabowski 2008): the mode of heating (direct or indirect), the energy source (electric or gas-fired), the mode of operation (batch or continuous), and the air movement within the oven (forced air circulation or natural convection).

As with other equipment, calculating the energy consumption of an oven implies taking into account not only the energy needed to heat the product, but also heat losses such as convection and radiation losses, energy needed to heat the conveyor belt or heat dissipated in the exhaust gases. Trystam, Brunet et al. (1989) and Christensen and Singh (1984) quantified the losses in different kinds of ovens, ranging from 80% to 95%. The high variability in the amount and types of losses prompts the recommendation to use empirical values such as those of Table 10.14, Appendix C.

4.2.12 OPERATIONS USING MOTORS

Many operations are carried out in apparatuses using a motor, such as pumping, mixing, cleaning, centrifugation, and size reduction. Cleaning of raw materials is usually the first operation in food processing. It allows for the removal of contaminating materials from the food, conditioning the food for further processing (Fellows 2000). The objective of mixing is to increase the homogeneity of material in bulk (Uhl and Gray 1966). It is also used to achieve additional effects, such as enhancing heat and mass transfer, accelerating reactions, and changing the texture (Berk 2009). Centrifugation enables the separation of heterogeneous mixtures by effect of centrifugal forces (Berk 2009).

The energy consumption of electric equipment (pumps and motors) is strongly related to its nominal power, a physical property describing the motor. Bieler, Fischer et al. (2003) propose the following equation for calculating the energy consumption of these apparatuses

$$E = \gamma P_N t \quad (4.23)$$

where γ is the fraction of nominal power consumed by the equipment; P_N the nominal power of the equipment (kW); and t the operation time (s). From measurements in plants, empirical values for γ are 28% for stirrers and motors and 52% for vacuum pumps (Bieler, Fischer et al. 2003).

In case γ and P_N are not known, equations based on momentum balances can be applied to calculate the energy for pumping (Eq 10.34 to 10.38 in the Appendix C).

4.3 CASE STUDY

As an application of the estimation toolbox presented in the previous sections, a case study is conducted and compared with data collected from a food processing company (Della Chiesa 2011).

Data of agricultural spinach production was taken from Stoessel, Juraske et al. (2012) Packaging was assessed as typically done in LCA, combining amounts of packaging material used (Table 10.15, Appendix C) with background data from inventory databases (ecoinvent v2 (Ecoinvent 2008)). Processing steps for the production of frozen spinach included selection and cutting, washing, blanching, packaging, freezing, and storage in a frozen storage room for 365 days. For these process steps, we used the tools shown in this paper to estimate energy demand (energy generation was again assessed from ecoinvent v2 (Ecoinvent 2008) data). Since data about machinery (processing, capacity, and power) from the spinach company were not available, we used the ones from a firm that develops machines for vegetable processing (Sormac 2013). Processing and storage in the households were not considered, as the purpose of the case study was merely to illustrate and evaluate the application of the tools developed in this paper.

To estimate the energy for freezing it was assumed that the product initial temperature (T_i) was +15 °C, the temperature of the cooling medium (T_f) −30 °C, the temperature in the center of the product at the end of freezing (T_c) −18 °C, and the product temperature at the end of the freezing process (T_p), calculated as the average between T_c and T_f, −24 °C. From the spinach composition (USDA), physicochemical properties were estimated as shown in Table 10.15, Appendix C. Table 10.16, Appendix C shows the values of the input parameters used in the calculations, the estimated energy consumption, the equations and the data sources applied. To calculate the uncertainty induced by the proposed toolbox, these data have been calculated assuming the maximum and minimum values according to the range of the input parameters and assumptions (e.g., fan heat load percentages in Table 10.11, Appendix C). Figure 4.2 shows the contribution of each life cycle stage to global warming potential (GWP) with results estimated from the toolbox compared to company data (Della Chiesa 2011). The GWP of the agricultural stage is in both cases the one from Stoessel, Juraske et al. (2012) for spinach produced in Switzerland.

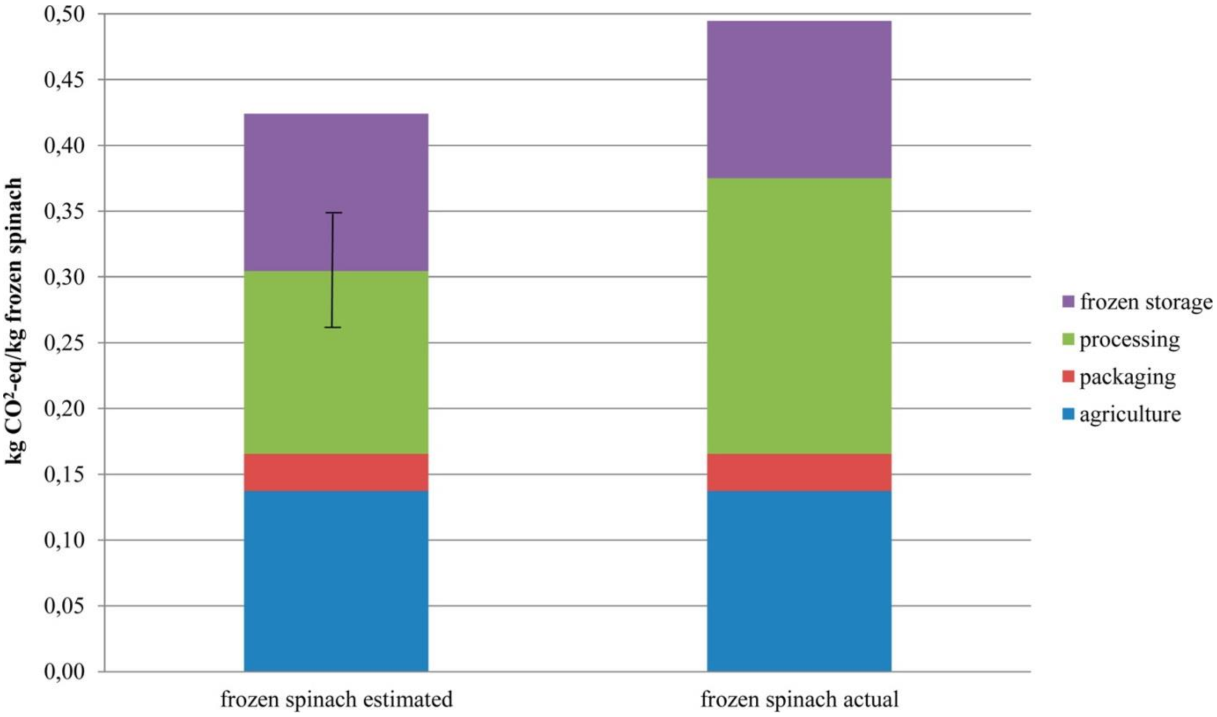

Figure 4.2 Impacts to climate change (GWP with 100 year time frame according to IPCC, 2007) per 1 kg of frozen spinach. The left column shows the results calculated with the toolbox developed in this paper (labeled as "estimated") and the right column shows the results calculated with actual inventory data from industry (labeled as "actual"). Processing includes selection and cutting, washing, blanching, packaging, and freezing.

As can be observed, processing is the stage contributing the most to the GWP, followed by the agricultural stage and the frozen storage, while the manufacturing of the packaging material is very low. These results highlight that processing and storage can be very important in the life cycle of some food products and therefore should be considered.

Results show that the estimations according to the models proposed in this paper present a good fit with the values of the previously published study (Della Chiesa 2011). Differences between the values estimated in this paper and the actual ones are 2.5% for frozen storage and between 25 and 65% in processing. They can be attributed to lack of details on the processing technology (e.g., kind of freezer and air rate in the freezer), which results in more uncertain estimates. As commented in the methods section, a description of the apparatuses used is important for an accurate estimation of the energy consumption. In spite of the data lack, the deviations between actual and estimated energy requirements were acceptable.

4.4 DISCUSSION

LCA studies of food products are often hampered by the lack of inventory data on food processing. While inventory data on primary agricultural production is increasingly published in databases (e.g., ecoinvent), there are many alternatives for food processing and very often such data is confidential. The present paper is a first step to bridge this data gap for a multitude of food products, by presenting models and data to estimate the energy demand of some important unit operations in food processing. Together with the recipe of products, which are often available from handbooks (e.g., Walstra, Geurts et al. (2005), Grainger and Tattersall (2005) and Hui (2006)), this will help to perform LCA studies of a multitude of food products and thus to support environmental decision making, e.g., on product choices, supply chain management, and process optimization. Models that estimate inventory data and environmental burdens can hence be vital tools to improve the environmental performance of food products and reduce the impacts of food consumption.

Energy consumption was shown to be a key inventory flow of food processing in previous LCA studies, but other data, such as water consumption and emissions to water and waste, would be needed to fully characterize unit operations in food processing and should be added in the future. Moreover, sometimes additives are used (called combined methods for food preservation). Estimation tools, such as FineChem (Wernet, Papadokonstantakis et al. 2009), can help to estimate the energy demand for the production of these chemicals. Furthermore, while the list of unit processes considered here is already rather extensive, some more specific processes are missing and need to be assessed in further work. The method proposed in this paper hence should be regarded as a starting point for further research activities.

Energy losses are not easy to quantify, and thus in some cases relationship equations or measured data from literature can be very useful. Minimum theoretical energy requirements computed from models can be taken as a lower bound of energy demand. Together with the losses, they allow for carrying out sensitivity analyses, revealing the most important drivers of energy demand and improvement potentials.

The case study completed and presented here shows good agreement between the measured and calculated data. Nevertheless, it is important to highlight the need to validate the proposed models with more case studies and measured data. This work is planned to be conducted in a follow-up project in collaboration with industry.

4.5 ACKNOWLEDGEMENT

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ASSESSING THE ENVIRONMENTAL IMPACTS OF AGRICULTURAL PRODUCTION ON SOIL IN A GLOBAL LIFE CYCLE IMPACT ASSESSMENT METHOD: A FRAMEWORK

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The individual contribution of Franziska Stoessel consisted of collecting and preparing the data, conducting the analyses and preparing the manuscript for publication.

ABSTRACT

A decrease in soil quality due to human activities, also known as soil degradation is associated with negative, in some cases even irreversible effects for ecosystem processes such as biotic productivity. Soil degradation encompasses effects like erosion, organic matter decline, salinization, compaction, landslides, contamination, sealing and soil biodiversity decline. In Life Cycle Assessment there are no comprehensive operational methods for the impact assessment of soil degradation yet. With this paper we propose a new framework for the impact assessment of soil degradation in agricultural production on regional as well as on global scale. It encompasses four aspects on soil degradation trying to avoid overlapping effects from different impacts. The impacts are quantified in terms of “long-term yield loss” and are aggregated to estimate the overall impact on the biotic production potential. In one example we show the Characterization Factors for soil compaction in integrated potato production. However, effort remains to make the framework operable also for other impact pathways than compaction.

5.1 INTRODUCTION

Sustainable management of soils is a key issue of modern times. Growing populations compete for food, fodder, fuel and fabrics and thus for soil that is essential for the production of the different assets. Soils have manifold functions besides biomass production: Soils build the physical environment for humans, they harbor biodiversity living belowground (Pulleman et al., 2012), they are the source of raw materials, they store carbon and finally they store, filter and transform nutrients, substances and water (McBratney et al., 2011). A decrease in soil quality due to human activities, also known as soil degradation, is associated to negative long-term and in some cases irreversible effects on soil functioning (Lal, 2009). These effects make the soil less fit for specific purposes such as crop production (Bindraban et al., 2012). The likelihood is high that degraded land will be compensated by gaining land through deforestation that causes additional negative impacts on the environment (Gomiero, 2016). As 25 % of the global agricultural land is said to already be highly degraded (FAO, 2011), it is urgent to stop the negative impacts on soils and to preserve its functioning.

Soil degradation is a combination of different negative impacts on soil quality. In Europe the most important processes leading to soil degradation are said to be erosion, organic matter decline, salinization, compaction, landslides, contamination, sealing and soil biodiversity decline. The costs of these impacts are estimated to be up to €38 billion yearly in the EU25. These estimates are rough due week quantitative and qualitative data (Montanarella, 2007).

Erosion removes the nutrient rich and organic matter dense upper layer of the soil by the force of unhindered wind or water power. The amount of material lost exceeds the amount of new built soil from pedogenesis. The global average erosion rate vary from 0.001-2 t soil/ha*yr in flat areas and 1-5 t soil/ha*yr in mountainous regions (Pimentel, 2006). This results in lower capability to fulfil functions as e.g. water runoff, water holding capacity or soil fertility.

Soil fertility is also degraded due to organic matter decline. This is the reduction of the share of organic matter in a soil. Reasons for that are erosion, drainage, cultivation practices and else. The organic matter decline thus reduces storage and availability of nutrients and it has a negative effect for instance on the soil structure.

Erosion and salinization are perhaps the most extensive degradation processes (DeLong et al., 2015). Soil salinization is the accumulation of soluble salts, mainly from Na, Mg and Ca due to poor irrigation technology, inappropriate drainage and the use of saline irrigation waters (Montanarella, 2007). It mostly occurs in arid and semi-arid agricultural regions (Año-Vidal et al., 2012).

Soil compaction generally describes the compression and shearing of soil pore structure. The outcome is reduced soil aeration, drainage capability, root penetration etc. It is induced by heavy machinery load or trampling on wet soils. The economic impact of soil compaction is estimated to be of the same magnitude as the impacts described above.

Landslides are mass movements of soils at slopes. Combinations of different conditions, as for example clayed subsoils, intensive land use through tourism and heavy rainfalls, can trigger landslides (Montanarella, 2007).

In many production processes substances are used, either direct (as pesticides) or indirect (for example as waste disposal). They can contaminate soils and harm agricultural production and groundwater.

All these soil degradation processes also decline soil biodiversity, which comprises at least one quarter to one third of all living organisms of the planet (Breure et al., 2012). It is essential for the metabolic capacity of the ecosystem and soil formation (Montanarella, 2007).

Additionally to the European key threats, desertification should be mentioned too. The UN Convention on Combating Desertification defined desertification as “land degradation in arid, semi-arid and dry sub-humid lands resulting from various factors including climatic variation and human activities”.

One method to identify the impact of production processes on soil degradation is the method of Life Cycle Assessment (LCA). In LCA there are only a few indicators addressing soil quality or soil degradation (Garrigues et al., 2012), though there is widespread recognition that more comprehensive indicators are needed (Milà i Canals et al., 2006; Nemecek et al., 2016). The barriers which have prevented such development include the complexity of soils and the lack of models for computer based simulations in regional assessment (Mutel et al., 2012).

Below we discuss existing approaches that try to quantify and assess soil quality, soil degradation and soil functioning. Methods assessing land use considering biodiversity as e.g. Chaudhary et al. (2015), ecosystem services and functions (Koellner et al., 2013), soil contamination, acidification and eutrophication are not discussed, because they are covered in other assessment methods.

5.1.1 ASSESSMENT METHODS FOR OVERALL SOIL QUALITY

Several existing approaches address soil organic matter (SOM). The most detailed approach is presented by Brandao et al. (2011) or Milà i Canals et al. (2007), where SOM is a sole indicator of soil quality. It is used as a proxy for soil quality, but it omits important drivers of soil quality loss like compaction and salinization (Hauschild et al., 2012) and sealing. The assessment requires SOM measurements for the inventory, but calculations of SOM content from models or values from literature could be used as well (Hauschild et al., 2012). It can be applied for agriculture and forestry only (Garrigues et al., 2012). The method SALCA-SQ (Oberholzer et al., 2012) assesses SOM too and adds eight other soil quality indicators affected by the agricultural management. It is said to be the method with the highest level of description of soil quality, accordingly the data requirement is high and it is calibrated for Swiss farms (Garrigues et al., 2012). The level of SOM is also suggested to be addressed by Cowell et al. (2000) and Achten et al. (2009). Cowell and Clift (2000) discuss allocation problems, occurring irregularly during one crop rotation, as well as changes in soil mass, nutrients, weeds and weed seeds, pathogens, the level of SOM, salts, the soil's pH and the form of the topsoil. All these factors are suggested to be considered. Achten et al. (2009) propose cation exchange capacity (CEC) and base saturation (BS) of the topsoil to quantify soil fertility and SOM of the topsoil and soil compaction (e.g. infiltration rate is used as a soil compaction indicator) to assess soil structure. Both are indicators for ecosystem structural and functional quality. The impact indicator scores are the relative impacts compared to the values in a system with potential natural vegetation.

5.1.2 ASSESSMENT METHODS FOR SINGLE SOIL DEGRADATION PROCESSES

The potential desertification impact of any human activity is included in an assessment method developed by Nunez et al. (2010). It considers variables such as the aridity index, water erosion, aquifer overexploitation and fire risk. The Characterization Factors (CF) for erosion are derived from the world map of the Global Assessment of Human induced Soil Degradation GLASOD. In a second study, a globally applicable, spatially differentiated LCIA method for assessing soil erosion was developed. The importance of regionalized assessment (e.g. site-dependent soil properties) was shown in a case study (Núñez et al., 2012). Feitz and Lundie (2002) propose a preliminary soil salinization impact model for the assessment of potential land degradation. The model is based on the relationship between the sodium adsorption ratio (SAR) and the electrolyte concentration (EC), which addresses soil permeability hazard and extent of soil dispersion, potential dispersion and flocculation. Its application is limited to soil salinization from irrigation practices. The model has to be adapted to particular sites, e.g. the electrolyte threshold curve. Leske and Buckley (2004) developed a salinity impact category, which addresses the total salinity potential for different compartments (atmosphere, surface water, natural surfaces and agricultural surfaces) relevant for South African conditions. Payen et al. (2016) presents a new framework for salinization that includes the studies above.

5.1.3 ASSESSMENT METHODS FOR SELECTED SOIL FUNCTIONS

The LANCA®-tool has been made operable for different mining and agricultural processes in selected countries. It quantifies the effects on four soil regulating services: mechanical filtration, physicochemical filtration, biotic production and groundwater replenishment (Beck et al., 2010). The model needs site-specific input data for several time steps, e.g. soil texture, declination, summer precipitation, type of land use, skeletal content, humus content, surface type for calculating erosion resistance etc. If specific data is not available the tool provides data on country-level. Differentiations between farming management practices are not possible (Beck et al., 2010). Saad et al. (2011) used the LANCA®-tool to calculate CFs for different spatial levels. The results highlighted the importance of using spatially differentiated Characterization Factors for the assessment of soil quality.

5.1.4 RESEARCH GAPS

The aforementioned methods address soil degradation due to agricultural processes without distinguishing different management practices and production standards. Furthermore, they do not consider all relevant aspects of soil degradation since they assess only single soil degradative processes. Some of the methods are limited to the assessment in specific countries. Moreover, most of the methods presented above are difficult to apply because of the excessive data requirements. Here, we will present a new framework for the impact assessment of soil degradation in agricultural production, applicable on regional as well as global scale (Figure 5.1). The framework includes the main drivers and impact pathways of compaction, organic matter decline, erosion, desertification, salinization and sealing. The impacts are quantified in terms of “long-term yield loss” and aggregated across the various impact pathways to estimate the overall impact on soil degradation.

5.2 THE FRAMEWORK

Some of the methods presented above are difficult to apply because of the excessive data requirements. We therefore set up a multi-level system, in which the LCA practitioner enters data on location, production standard, the kind of crop and the “use” of constructed area. This information allows for the query in a background database containing relevant information on e.g. soil texture, weather data, elevation, slope and land use including machinery use, its specification and else. The information acquired from the data base query is consequently used to calculate regionalized Characterization Factors (CFs). The spatial differentiation is relevant when studying territories with heterogeneity in environmental characteristics (Nitschelm et al., 2016) as it is the case for soils. Local weather data is relevant for soil degradation as well. Today’s weather data is available globally and regionalized (e.g. www.meteonorm.com) and including it into the model is a necessary next step improving the quality of LCIA. In the background database we also provide standard datasets about agricultural practices in different production systems and for different crops. These datasets can be adapted when more accurate data is available.

The nine main soil threats we consider in our framework are erosion, organic matter decline, salinization, compaction, landslides, contamination, sealing, soil biodiversity decline and desertification. They are related directly or indirectly up to different degrees. In order to avoid double counting of impacts it is reasonable to carefully make a selection of relevant impacts. Soil organic matter (SOM) was considered to be the most appropriate indicator for soil quality in LCA and CFs were calculated for eight land use types on the climate region level (Brandao and Canals, 2013). To the same conclusion came Milà i Canals and de Baan (2015) when they described the state of the indicators. But Milà i Canals et al. (2007) stated that not all aspects of soil quality are represented by SOM. Erosion, compaction, build-up of toxic substances, acidification and salinization are not directly assessed by using SOM as an indicator. We therefore suggest using soil organic matter as a proxy for erosion, soil organic matter decline and desertification. Additionally, we suggest considering soil compaction, salinization and sealing in order to have an accurate set of impacts for the assessment of soil degradation. The remaining threats are landslides and soil biodiversity decline. Landslides are indeed important threats to the soil but are not in the focus when assessing agricultural processes (except for land use changes, such as deforestation and land abandonment (Montanarella, 2007)). Soil biodiversity decline could be integrated in biodiversity impact assessment methods. However it is also represented in the assessment of SOM, that is crucial for soil biodiversity (Montanarella, 2007).

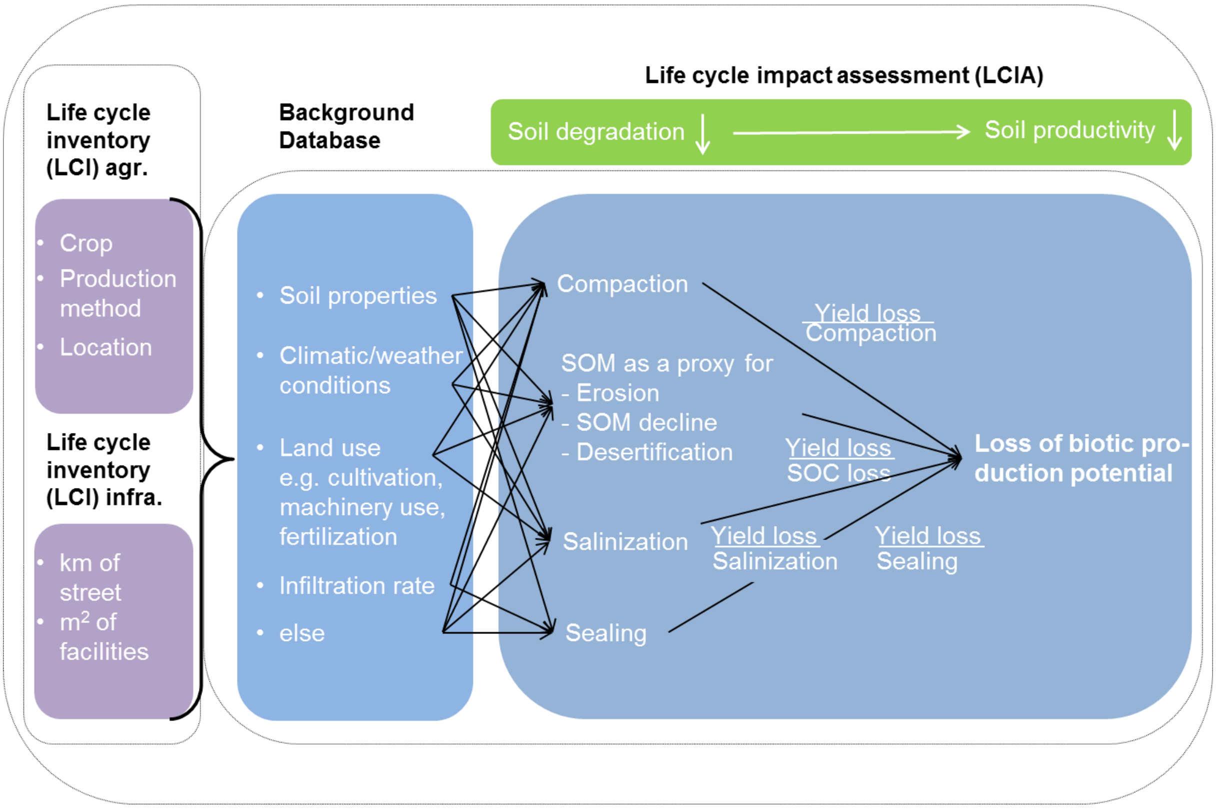

Figure 5.1. Impact pathway of soil degradation processes on soil productivity.

The framework we suggest includes the main drivers and impact pathways of the four selected aspects of soil degradation: Compaction, soil organic matter decline, salinization and sealing. Impacts are then quantified in terms of "long-term yield loss" and aggregated across the various impact pathways to estimate the overall loss of biotic production potential through soil degradation (Figure 5.1).

The application of the framework is illustrated for the impact of soil compaction (Figure 5.1).The model of Arvidsson and Hakansson (1991) was adapted to assess yield losses through soil compaction in a regionalized manner, with global coverage. The background database comprises crop production data (with around 150 crops and production methods – organic and integrated production standard), regionalized soil texture data (ISRIC - World Soil Information, 2013), soil moisture data and machine specifications for all machines used in crop productions. A publication about the development of a new soil compaction method, based on the model of Arvidsson and Hakansson (1991), with a set of background data and readily applicable CFs is in preparation.

Characterization Factors for the assessment of soil organic matter decline have been developed and tested by various researchers, for example by Goglio et al. (2015), Mattila et al. (2012) or Morais et al. (2016). The IPCC provides relative carbon stock change factors for soil (IPCC, 2006). These factors are available for different land-use types (e.g. long- and short-term cultivated cropland or permanent grassland) as well as land-use management types (e.g. different tillage and fertilization practices). Furthermore, they provide estimations of the initial carbon stock of the natural vegetation in different climate regions. Brandão and Milà i Canals

(2013) used the SOC values and change rates to develop a LCIA method (with CF) for the biotic production potential. For our goal we need an extension of the method by Brandão and Milà i Canals (2013) to relate crop specific yield and SOC change (ΔC year^{-1} m^{-2}). There are two ways to do so: One is to estimate the yield loss via nutrient stock change. The available nitrogen (N) mineralized from SOM (NH_4^+ and NO_3^-) can be taken up by plants, but will also get lost partly via leaching, volatilization or denitrification, which should be considered. Bontkes and Keulen (2003) suggested that 25% of the mineralized N are lost via volatilization and denitrification. Estimations of leaching are more difficult to make as it largely depends on the actual rainfall amount. More accurate estimations might be possible using the method SALCA-NO_3 (Richner et al., 2014). As crop yields do not solely depend on the N supplied by the soil, the N supplied by the organic or synthetic fertilizer has to be taken into account. Finally, yield can be predicted using nitrogen-yield response curves. Nitrogen-yield response curves were firstly suggested by Eilhard Alfred Mitscherlich (Harmsen, 2000). Mueller et al. (2012) used Mitscherlich-Baule nitrogen-yield response curves to estimate global maximum attainable yields for different crops considering fertilizer application, irrigation and climate. Alternatively, crop yields and SOC content in response to fertilizer management could be modelled using crop growth models. Those models were already used in other LCA studies (Adler et al., 2007; Kim et al., 2009; Veltman et al., 2014). With crop growth models such as Daycent (Del Grosso et al., 2008) or CropSyst (Stöckle et al., 2003) that take climatic and soil conditions into account, the yield of specific crops could be modelled for different fertilizer scenarios. Furthermore, the effect of a certain management scenario can be evaluated over many years and taking crop rotations into account as well as restoration time.

Payen et al. (2016) evaluated the existing Life Cycle Impact Assessment methods addressing salinization. She proposed a three-stage approach for the setup of a relevant and complete model to assess salinization impacts in LCA. It will focus on anthropogenic salinization and considers salinization associated with land use change, irrigation, brine disposal and overuse of a water body (e.g. through seawater intrusion). However, this approach is still on a conceptual level and not yet operational. For soil degradation we would select the impacts associated with land use change, irrigation and brine disposal. That leads to the proposed midpoint indicator "soil fertility and structure decline". The normalized CFs could be used in the relationship of soil salinity and energy harvested by photosynthesis as (described in Munns and Gilliham (2015)). The energy harvested in turn can serve as an indicator for yield loss. The average crop specific salt tolerance (Katerji et al., 2000) has to be considered by implementing another factor reflecting the crop differences. Effects of salinity have been studied in various field experiments for different crops (e.g. Katerji et al. (2003) or Kim et al. (2016)). These results could be used to verify the results.

For the impact of sealing we propose a very rough estimate. Up to date we are not aware of existing LCIA methods considering sealing aspects. But we are aware of the importance to include sealing impacts into LCIAs of agricultural products. Our suggestion is to use the runoff curve number as a proxy for the sealing intensity of roads, buildings and other infrastructure. The runoff curve number is dependent on the intensity of the sealing (Maurer et al., 2012). The amount of area "used" in a production of a product is multiplied with the runoff curve number given in construction guidelines for the rainwater runoff (e.g. Petschek (2015)). The result will afterwards be multiplied with the yield of the according crop, in order to get a proxy for the yield loss through sealing.

As described above, we propose to consistently address four soil degradation processes and express them in the same unit, to make their soil degradation effect comparable. However, since the effects of compaction, SOM loss, salinization and sealing are not linearly additive, we propose to use a similar approach as followed by the response addition concept for the assessment of chemical mixtures. For multiple mixtures it is described as follows:

$$E(mix) = E(y_1, y_2 \dots y_n) = 1 - \prod_{i=1}^{n} (1 - E(c_i))$$

With n = number of compounds, $E(c_i)$ = effect level resulting from yield loss y_i of compound i applied on its own and E(mix) = effect resulting from mixture (De Zwart and Posthuma, 2005). It allows combining different effects with dissimilar modes of actions. The applicability to different soil degradation effects should be investigated by empirical observations.

5.3 EXAMPLE: SOIL COMPACTION

To illustrate our method, in the following we present a set of CFs (expressed in % yield loss) for compaction applicable for potato production (Figure 5.2). It is calculated under the assumption that potatoes are grown everywhere and on wet soils. It is therefore not a realistic picture but it shows the possible extremes.

5.4 DISCUSSION AND CONCLUSION

Many attempts have been made in the last few years to include soil degradation impacts in LCIA but no one was able to cover the whole spectrum of soil degradation. Our attempt outlines a framework that aims to achieve this goal. Challenges include finding the right balance between detail and completeness. The question of reference state and uncertainty should also be investigated. The implementation of our method is illustrated for the impact pathway of soil compaction (Stoessel et al., 2018). In the future, we aim to include the other aforementioned impact pathways in our method in a consistent manner and to integrate the whole method for soil degradation in existing LCIA methods. The applicability also depends on the flexibility of LCA software to use regionalized impact assessment methods. Special attention has to be given in avoiding double counting, when the method is used together with future other methods.

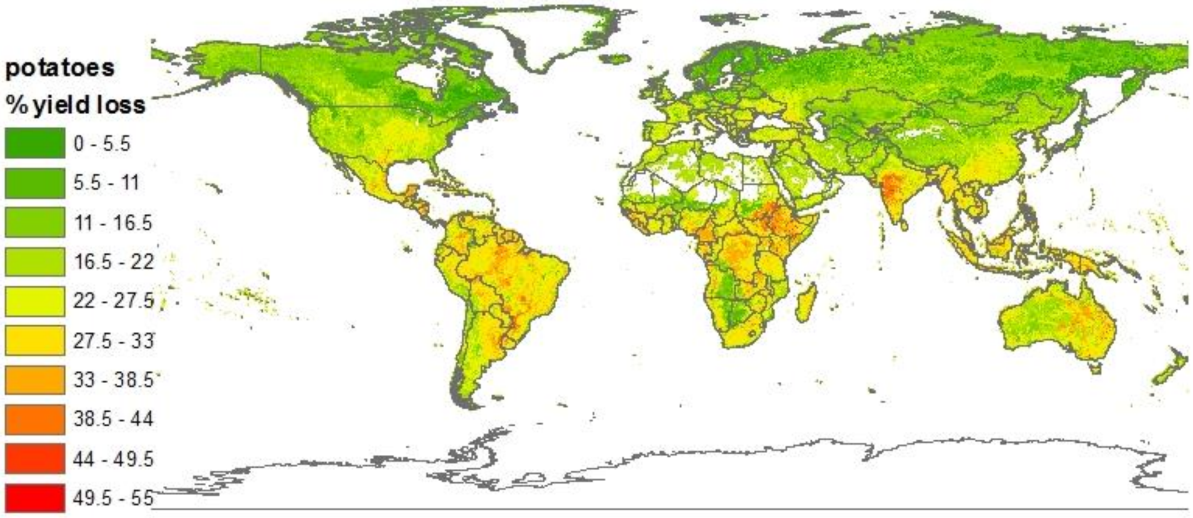

Figure 5.2. Yield loss of potatoes due to soil compaction. Results show a worst case scenario with high soil humidity and high production intensity in integrated production. Differences in yield losses are driven by varying soil texture.

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CHAPTER 6

ASSESSING THE ENVIRONMENTAL IMPACTS OF SOIL COMPACTION IN LIFE CYCLE ASSESSMENT

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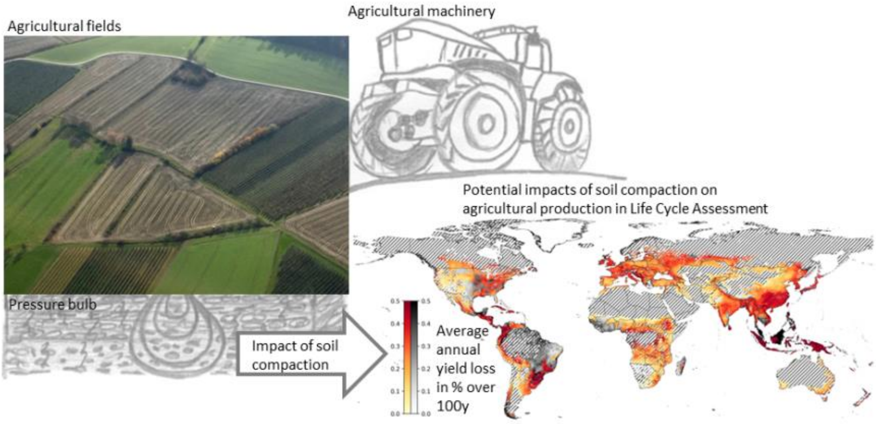

Figure The TOC art submitted with the article.

Highlights

- Presentation of a method to assess soil compaction in Life Cycle Impact Assessment.
- Quantification of the soil compaction impact in % yield loss for crop production.
- Applicability of the method to various spatial scales and production systems.
- Adapting the crop in mechanized systems is effective in reducing compaction impact.
- Vulnerability to compaction impact is highest in moist soil with high clay content.

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The individual contribution of Franziska Stoessel consisted of collecting and preparing the data, code-contributions, conducting the analyses and preparing the manuscript for publication.

ABSTRACT

Maintaining biotic capacity is of key importance with regard to global food and biomass provision. One reason for productivity loss is soil compaction. In this paper, we use a statistical empirical model to assess long-term yield losses through soil compaction in a regionalized manner, with global coverage and for different agricultural production systems. To facilitate the application of the model, we provide an extensive dataset including crop production data (with 81 crops and corresponding production systems), related machinery application, as well as regionalized soil texture and soil moisture data. Yield loss is modeled for different levels of soil depth (0-25 cm, 25-40 cm and > 40 cm depth). This is of particular relevance since compaction in topsoil is classified as reversible in the short term (approximately four years), while recovery of subsoil layers takes much longer. We derive Characterization Factors quantifying the future average annual yield loss as a fraction of the current yield for 100 years and applicable in Life Cycle Assessment studies of agricultural production. The results show that crops requiring enhanced machinery inputs, such as potatoes, have a major influence on soil compaction and yield losses, while differences between mechanized production systems (organic and integrated production) are small. The spatial variations of soil moisture and clay content are reflected in the results showing global hotspot regions especially susceptible to soil compaction, e.g. the South of Brazil, the Caribbean Islands, Central Africa, and the Maharashtra district of India. The impacts of soil compaction can be substantial, with highest annual yield losses in the range of 0.5% (95% percentile) due to one year of potato production (cumulated over 100 y this corresponds to a one-time loss of 50% of the present yield). These modeling results demonstrate the necessity for including soil compaction effects in Life Cycle Impact Assessment.

6.1 INTRODUCTION

Soil systems have different functions including biomass production, building the physical environment for humans and harboring biodiversity. Moreover, soils are a source of raw material and they store, filter and transform a broad range of substances, such as nutrients (including carbon) and water (McBratney et al., 2011). The fulfilling of these functions depends on a soil's quality (Greiner et al., 2017). Soil quality is characterized by biological, chemical, and physical properties, processes and interactions within the soils. The evaluation of soil quality is not straightforward because governing parameters differ from site to site and depend on the management goal (Karlen et al., 2003). Soil systems are highly heterogeneous. Their consistencies vary horizontally and vertically in space and time. All these aspects represent major challenges in quantifying and comparing impacts of human actions on soil quality worldwide. The importance of soil quality to produce food, fodder, fuel and fabrics was already recognized in the 1980s (Karlen et al., 2003) and it received increased attention within the discussion about how to feed the world's growing population (Bringezu et al., 2014). Stagnation or a decrease in productivity due to soil degradation causes economic loss and affects food security (Bindraban et al., 2012).

Soil degradation is defined as adverse changes in soil properties and processes leading to a reduced capacity of the soil to provide ecosystem functions (Lal et al., 2003). Soil degradation impacts are often long-term and sometimes irreversible (Blume et al., 2010). The main threats to soil are erosion, loss of organic matter, compaction, salinization, landslides, contamination, sealing (European Comission, 2012; Grunewald and Bastian, 2012), soil biodiversity loss, desertification and decline in fertility (Haygarth and Ritz, 2009; Lal, 2009; Lal et al., 2003; Muchena et al., 2005). On a worldwide level, deforestation and agricultural mismanagement are, among others, severe causes of soil degradation (Lal et al., 2003; Muchena et al., 2005). In order to prevent further soil degradation and to restore degraded soils, the European Union harmonized existing soil monitoring networks (Kibblewhite et al., 2008). On the global scale at 1:10 million, GLASOD (Oldeman et al., 1991) was the first assessment on the status of human-induced soil degradation (Sonneveld and Dent, 2009). It was established for policy makers as a basis for priority setting in their action programs. Soil scientists throughout the world gave their expert opinion according to general guidelines on soil degradation in 21 geographic regions (Oldeman et al., 1991). Two categories of degradation processes were assessed. One category contains effects of soil displacement (mainly erosion degradation). The second category estimates soil degradation caused by other physical and chemical deterioration. Despite its limitations, GLASOD remains the only complete, globally consistent information source on land degradation (Gibbs and Salmon, 2015). Rickson et al. (2015) stated that the extent of compacted soil in Europe is 33 million hectares. The number has its origin in the soil degradation survey of Oldeman et al. (1991). This corresponds to 18% of Europe's agricultural land, when considering the total agricultural land of the EU28 in 2013 (Eurostat Statistics Explained, 2015). Since the weight of agricultural machinery has increased (Batey, 2009; Hakansson and Reeder, 1994; Kutzbach, 2000; van den Akker, 2004), the problem may even be more pronounced today. Estimates of areas at risk of soil compaction vary. Some authors estimate that 36% of European subsoils have a "high or very high susceptibility" to compaction, other sources report 32% of European soils as being "highly susceptible" and 18% as being "moderately affected" (Jones et al., 2012).

Soil compaction is defined as a "negative" change in the volume shares of the three phases of a soil, i.e. the solid phase, the water and the air-filled spaces. Such a change may be due to compression and/or shearing of the soil pore structure (Blume et al., 2010). The compaction status can be characterized by the relative bulk density, which is the bulk density normalized by laboratory-defined reference states (Hakansson and Lipiec, 2000) or by the penetration resistance (Martínez et al., 2016). Soil compaction affects the function of the pores to store and transport water and gases, nutrients and heat, which is essential for plants and animals to live and grow (Blume et al., 2010). The resulting impact includes the risk of yield reduction, erosion, and reduced water infiltration capacity that may even cause floods after heavy rainfall (Nawaz et al., 2013; Van der Ploeg et al., 2006). In compacted soils, apart from drowning the crops in logged water and disturbed nutrient regimes, microorganisms are not able to work and penetration of agricultural crops' roots is hindered. To make up for yield losses, farmers often apply additional fertilizer to their crops (O'Sullivan and Simota, 1995). Higher fertilizer applications in wet soils cause e.g. more nitrous oxide emissions, which is a highly potent greenhouse gas (Nawaz et al., 2013). Other emissions from fertilization contribute to eutrophication.

Animal trampling and the use of heavy agricultural machinery are the main causes for soil compaction on agricultural land (Bilotta et al., 2007). Wet soils with high clay content and low organic matter are particularly sensitive to impacts of compaction. Clay-organic matter interactions are stabilizing soil aggregates, and to a certain degree, these aggregates are able to absorb the pressure. The stability of the aggregates is weaker in wet soil and the structure is more destroyed at higher pressure (Van der Ploeg et al., 2006). The deeper the compaction occurs in the soil, the less possibility of restoration (Jones et al., 2012). Mechanical deep tillage makes soils even more susceptible for re-compaction after heavy equipment passes over again (Håkansson, 2005; Spoor, 2006).

To implement a better trafficking system, several mechanistic methods are used for the assessment of "soil compaction", e.g. Biris et al. (2011), Keller et al. (2007), Stettler et al. (2010) or van den Akker (2004). These models are accurate for calculation of the physical impact, such as soil stress versus soil strength for every tire of an agricultural machine at certain environmental conditions. However, they require information on a level of detail that is typically not available to Life Cycle Assessment (LCA) practitioners. Furthermore, the model output often refers to single process steps for the real time management in crop growing without considering entire growing cycles.

Existing Life Cycle Impact Assessment (LCIA) methods related to soil quality are highly heterogeneous (Vidal Legaz et al., 2017). They either provide indicators for soil properties, like soil organic matter (SOM) or soil threats (erosion or desertification etc.). Some methods assess the provision of ecosystem services based on soil functions. Despite methodological improvements, soil quality aspects in LCIA need to be improved (Dijkman et al., 2018). In a previous paper we introduced a framework for consistent LCIA of soil degradation (Stoessel et al., 2016), which we enhanced with further detail in Figure 6.1a).

Applications of environmental LCA to evaluate future food systems need to assess a broad variety of environmental impacts in order to avoid burden shifting. The heterogeneity of agricultural production systems and locations has to be taken into account. The goal of this work was to fill the gap in LCIA regarding impacts of soil compaction on a global level with high spatial resolution and being able to assess different agricultural systems. In this paper, we provide an operational method for the assessment of long-term yield reduction due to soil compaction in LCIA. To facilitate the application to agricultural activities, we establish and provide a dataset about machinery use for 81 crops and their growing cycle in various mechanized production systems. This is of particular interest to assess soil quality impact when comparing different production systems like organic and conventional production (Nemecek et al., 2011). Furthermore, this method is applicable on a global, regional or local scale. The global application of the new method and data to the cases of wheat and potato production with a spatial resolution of 1x1 km illustrates the extent of potential impact.

6.2 MATERIALS AND METHODS

6.2.1 MODEL OVERVIEW

We use the empirical model of Arvidsson and Hakansson (1991) to calculate yield loss induced by soil compaction. This model is based on a statistical analysis of results obtained from Swedish field trials (Arvidsson and Hakansson, 1996). The applicability is not restricted to Sweden (Lipiec et al., 2003) and an adapted version was successfully tested in Australia for perennial crops (Braunack et al., 2006). The model is relevant to tillage systems that include ploughing. It considers an entire crop growing cycle and the results are calculated for three soil layers (0-25 cm, 25-40 cm and > 40 cm depth).

The model input needed is partly crop dependent and partly soil dependent. Crop dependent inputs are machine types and their specifications (i.e. working width, machine weight, and tire pressure), the number of passes per growing cycle and extra traffic on the field (e.g. for turning). Soil dependent inputs are soil moisture and clay content. The data and their origin are shown in Table 6.1.

Table 6.1 Overview of data used in the modeling.

		References
Crop dependent inputs	**Machinery use**	agridea and FiBL (2012)
	Machine specification	Arvalis (2004), Agrar (2014), Stettler et al. (2010), New Holland (2014), Gazzarin (2016), Maschio (2012), Becker (2014), Holmer (2014), Capaul and Riedi (2012), Michelin (2011), Keller (2005), Diserens et al. (2011), Battiato and Diserens (2013), Diserens (2011), Schjønning et al. (2008), Diserens et al. (2004), Schjonning et al. (2012), Bastgen and Diserens (2009), Diserens (2009), Lamande and Schjonning (2008), BAFU und BLW (2013), Grimme (2014), Claas (2013), Stoessel (2018)
Soil dependent inputs	**Soil moisture**	Trabucco and Zomer (2010), Siebert et al. (2013), Lüttger et al. (2005)
	Soil clay content	Hengl et al. (2017)

With this input, so-called corrected tonne-kilometers per ha (tkm-corr/ha) are calculated, which represent a proxy for the pressure on the soil exerted by the machinery (i.e. the stressor causing soil compaction) during one growing cycle on one ha. These values are then translated into a yield loss.

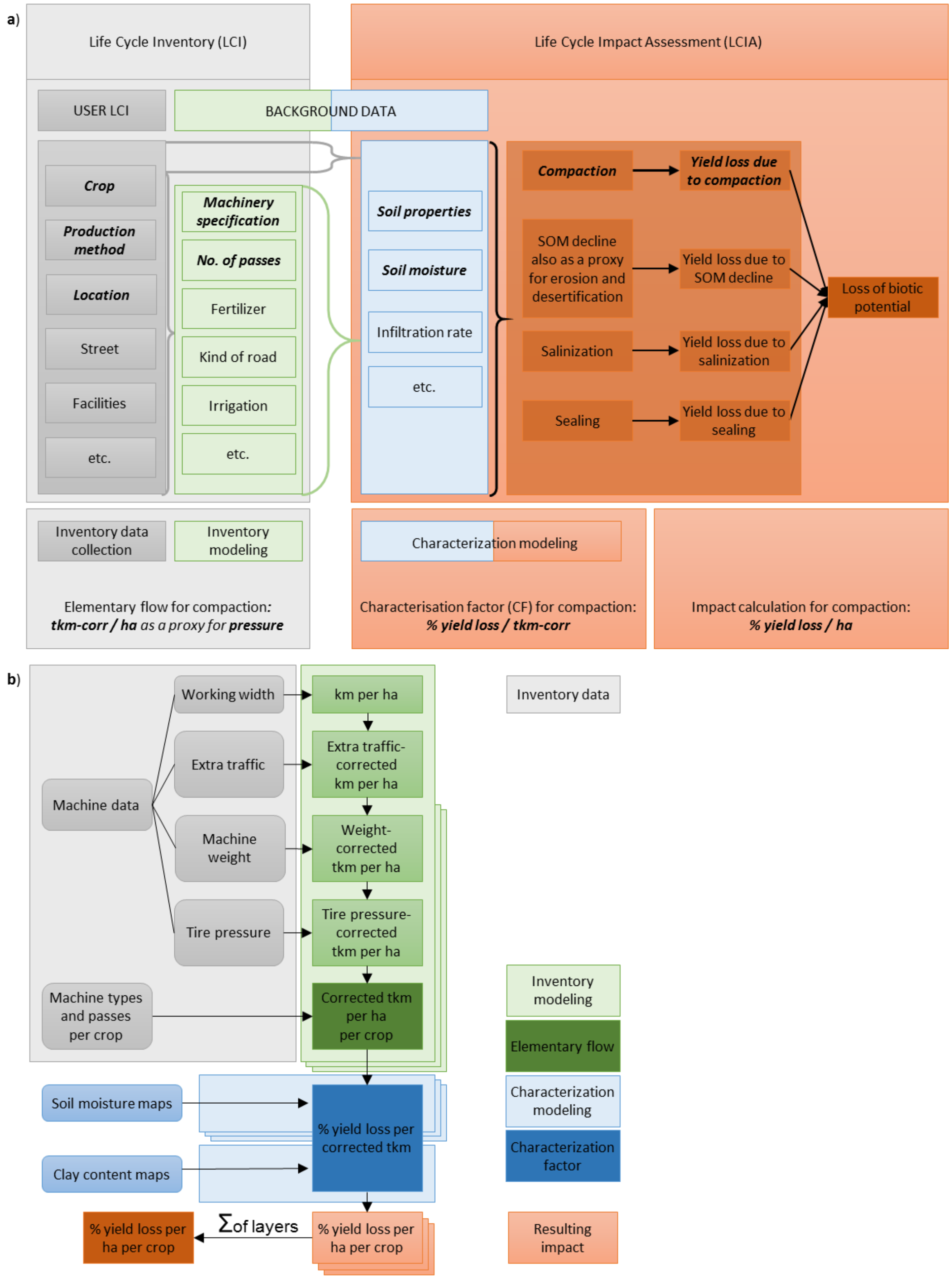

Figure 6.1 a) Framework for impacts of soil degradation processes on soil productivity modified from Stoessel et al. (2016). The new impact pathway for agricultural soil compaction is highlighted in bold, italic (SOM: soil organic matter, tkm-corr/ha: corrected tonne-kilometers per ha). b) Detailed modeling approach for soil compaction. Calculation of Elementary Flows and Characterization Factors for three soil layers; rounded boxes represent the model input, layered rectangles represent the three soil layers for which separate calculations are made.

6.2.2 MODEL ADAPTATION FOR LCA: CALCULATION OF ELEMENTARY FLOWS AND CHARACTERIZATION FACTORS

For our purposes, the model has been separated into two main parts in order to calculate an Elementary Flow (an exchange between technosphere and biosphere) and a Characterization Factor to calculate the impact. The crop dependent part, considering machinery data, is used to calculate a proxy Elementary Flow in corrected tonne-kilometers per ha, representing the cumulated pressure from machinery (technosphere) on the soil (biosphere). In the quantification of Characterization Factors, soil characteristics are taken into account to calculate spatially resolved Characterization Factors, translating the Elementary Flow into damage, measured as yield loss (Figure 6.1b). The procedure is described in more detail in the following paragraph.

The distance driven per ha and machine is calculated based on the working width of the machine and a correction for extra traffic (e.g. turns on the head of the field). The result is a corrected distance in km per ha. This distance again is corrected for weight on the different axles of the tractor and trailers and for the tire-pressures, since these factors affect pressure on the soil and the propagation downwards to the deeper soil layers. Accordingly, the corrections are calculated for the three soil layers. Tillage practices and non-tillage practices are treated separately. The corrected tkm/ha for each machine application are multiplied by the number of passes per crop and ha, and these results are summed (separately for each of the three soil layers). The resulting total corrected tkm per ha, crop and layer is the new Elementary Flow suggested as a proxy for pressure on the soil. Along with productivity information (yield per area), this flow can also be calculated per amount of crop, as typically done in a life cycle inventory (LCI).

In order to calculate the percent yield loss per ha and crop, the corrected tkm per ha are multiplied with an empirically derived factor considering soil moisture and a factor considering the clay content of the soil (the latter is only done for the top soil layer) (Arvidsson and Hakansson, 1991). Both factors combined build the Characterization Factors for the three soil layers, and they directly translate the corrected tkm per ha into percent yield loss (for each crop and the soil layer).

Topsoil compaction is less persistent than subsoil compaction, which is almost irreversible and very difficult to treat mechanically (Arvidsson, 2001). We adopt the assumption of Arvidsson and Hakansson (1991) that the top soil layer (0-25 cm depth) recovers within 4 years, while the effects of compaction in the mid soil layer (25-40 cm depth) are assumed to persist for 10 years. The model estimates the cumulative yield loss for all years and expresses it in percent of one year's yield (Arvidsson and Hakansson, 1991). The compaction impacts in the bottom soil layer (> 40 cm depth) are considered to be permanent (Braunack et al., 2006). In order to aggregate the bottom soil layer impacts with those of the other soil layers, a time horizon of 100 years has been chosen and impacts for one year's yield of the top and mid soil layers are divided by 100 accordingly (Equation 6.1). Results are presented as average annual yield loss (for all layers) in percent of the reference yield without further compaction for all the following crops during the next 100 years.

$$\varnothing\ \text{annual yield loss}_{100\text{y}} = \frac{\%\ \text{yield loss}_{\text{top soil}}}{100\text{y}} + \frac{\%\ \text{yield loss}_{\text{mid soil}}}{100\text{y}} + \%\ \text{yield loss}_{\text{bottom soil}}/\text{y} \quad \text{(Eq 6.1)}$$

Since compaction effects showed to be cumulative in previous studies (Braunack et al., 2006), compaction impacts are assumed to be additive. In reality, there is presumably an equilibrium state. An aggregation is useful for common LCA studies, but the method outlined here can also be used without aggregation, if the goal of the study is to model impacts dynamically as a function of time. With regard to the recovery times of 4 years in the top soil layer and 10 years in the mid soil layer, this would mean spreading the model outputs for these layers in a way over the recovery times that the recovery can be approximated by a linear trend. An example is provided in Figure 6.2.

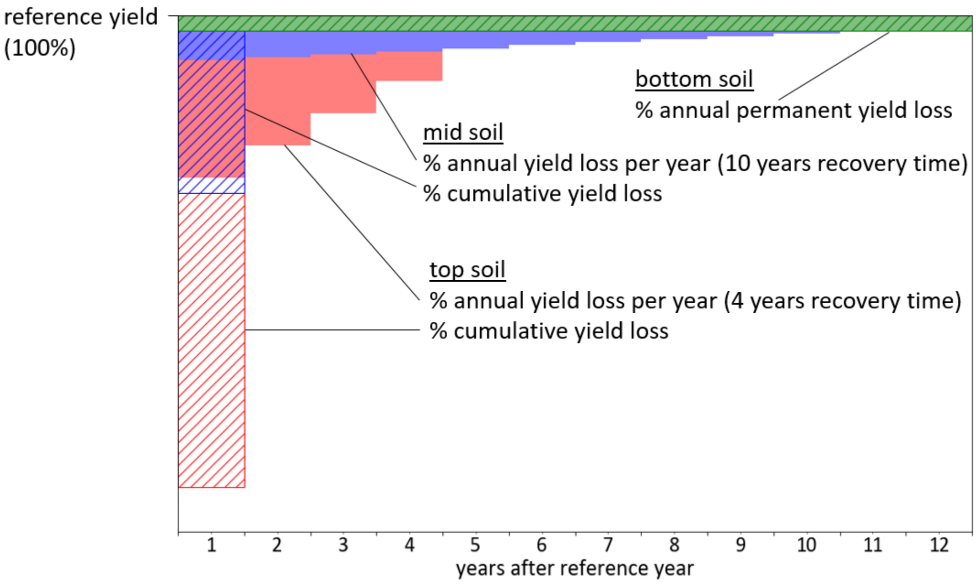

Figure 6.2 Dynamic impact modeling with linear recovery, in case of the top soil layer within 4 years, in case of the mid soil layer within 10 years; areas represent yield losses in % of yield in the reference year; hatched: model output, filled: model output assigned to different years with linear recovery, red: top soil layer, blue: mid soil layer, green: bottom soil layer.

6.2.3. MODEL INPUT: PRODUCTION AND MACHINERY SPECIFICATION DATA

The choice of specific agricultural machines used in growing crops depends on the crop type, their position in the crop rotation, the production system and other factors. Following the proposal of Stoessel et al. (2016) to reduce the data requirement for the user in LCA, we set up a multi-level calculation system. In this system, the user only needs to provide data on the type of crop, the production system, and the location. The latter is used for selection of the spatially explicit Characterization Factor that is available in a resolution of 1 km. As shown in Figure 6.1a), this information allows for the query of a dataset containing the relevant information on the corresponding default machinery data that is currently provided independent of the location and should be adapted in case of strongly deviating production conditions.

Two distinct datasets were collected to set up this database. First, the machinery used during the entire growing cycle of 81 crops is compiled. This includes the number of passes that every machine does during one growing cycle. In the current version, this is derived from production cost calculation sheets (agridea and FiBL, 2012) for Switzerland. The resulting dataset contains the necessary information on integrated and organic crop production. The key elements that mark the integrated crop growing system are equilibrated nutrient balance, ecological compensation areas on at least 7% of the farm area, diversified crop rotation, soil protection during winter and targeted pest management (Nemecek et al., 2011). Organic growing systems include the key elements of the integrated production systems and in addition - as key characteristics - they do not allow the use of chemically synthesized pesticides and fertilizers and genetically modified organisms. The dataset is presented in Appendix D, Section 11.6, and future work can extend it to other crops and production systems.

The second type of dataset comprises the specifications (such as type, weight, working width, or tire inflation pressure) of the different machines in the first dataset. The data sources are given in Table 6.1. The choice of the agricultural machinery is the most important man-made factor that influences soil compaction, since the wheel load generates the physical pressure on soil. In our dataset, no special efforts to reduce the wheel load, like twin-tires or reduced machine weights, are considered. In future work, the dataset (Appendix D, Section 11.7) can be extended to include other machines.

6.2.4 MODEL INPUT: SOIL MOISTURE DATA

The model requires an estimation of soil moisture content of the topsoil and subsoil layer on a scale from 1 (dry soil) to 5 (wet soil) (Braunack, 1999). Values for the soil stress coefficient from Trabucco and Zomer (2010), ranging from 0 to 1, have been fitted to this scale (and rounded to one decimal place) by Equation 6.2 in order to provide a soil moisture content value (SMCV) for the modeling of the Characterization Factors. This value is used for both soil layers.

$$SMCV = soil\ stress\ coefficient \times 4 + 1 \quad \text{(Eq 6.2)}$$

The soil stress coefficient is the ratio of the monthly soil water content (SWC) divided by the maximum SWC, which is the difference between SWC at field capacity and the SWC at the wilting point. This difference is sometimes also referred to as available water capacity (AWC) (Trabucco and Zomer, 2010). Furthermore, irrigation data has been taken into account. The area actually irrigated as a percentage of total area (of a raster cell in a global raster) has been calculated with data from Siebert et al. (2013). It is assumed that soils under irrigation are irrigated up to a soil stress coefficient of 0.5. A value of 0.5 to 0.8 is optimal for plants (Lüttger et al., 2005), corresponding to a soil moisture content value of 3. The final value of the soil moisture content in a raster cell with irrigation is calculated according to Equation 6.3, which simply computes the area weighted average of the SMCV and the irrigation value (which is 3).

$$\mathrm{SMCV_{irrigated}} = \frac{\mathrm{area_{irrigated}}}{\mathrm{area_{total}}} \times \mathrm{SMCV} + \frac{\mathrm{area_{not\ irrigated}}}{\mathrm{area_{total}}} \times 3 \text{ (Eq. 6.3)}$$

Soil moisture data at monthly resolution has been run through the model equations and then averaged to a yearly soil moisture correction factor. However, monthly correction factors and hence monthly Characterization Factors could also be calculated.

6.2.5 MODEL INPUT: SOIL CLAY CONTENT

One of the basic parameters for running the model is the clay content of the top soil layer (Arvidsson and Hakansson, 1991). For our case study, we use datasets from SoilGrids250m (Hengl et al., 2017). This is a global soil information system at 250 m resolution, which is set up by the Institute for World Soil Information (ISRIC). It is based on approximately 110’000 soil profiles from conventional soil surveys and climatic, lithological, biological indices. Among other soil information, it provides global maps of (modeled) clay fractions at seven standard depths. In order to calculate the clay content for the top soil (0-25 cm), the top four layers (0, 5, 15, 30 cm) have been averaged as suggested by Hengl et al. (2017). For compatibility with the spatial data of soil moisture, the clay content data are aggregated to a grid resolution of 1 km using the resample-algorithm of ArcGIS 10.5.

6.2.6 METHOD APPLICATION COMPARING PRODUCTION SYSTEMS

The comparison of the modelled inventories allows studying the influence of the crop production system on compaction. This is calculated for 24 pairs of crops in organic and integrated production according to Equation 6.4.

$$\Delta_{\mathrm{organic-integrated}}\ [\%] = \left(\sum\nolimits_{\mathrm{crops}} \frac{\sum_{\mathrm{layer}} \mathrm{tkm_{crop,(organic)}} - \sum_{\mathrm{layer}} \mathrm{tkm_{crop,(integrated)}}}{\sum_{\mathrm{layer}} \mathrm{tkm_{crop,(integrated)}}} \times 100\right) / 24 \text{ (Eq 6.4)}$$

Where $\sum_{\mathrm{layer}} \mathrm{tkm_{crop,(organic)}}$ is the sum of the modeled tkm of one organic crop and for the three layers, and $\sum_{\mathrm{layer}} \mathrm{tkm_{crop,(integrated)}}$ for integrated production, respectively. The combination of inventory and Characterization Factors then allows quantifying the magnitude of impact considering both crop and site factors.

6.3 RESULTS AND DISCUSSION

6.3.1 LCI ELEMENTARY FLOW

The corrected tonne-kilometers per ha, as a proxy for the pressure on soil that subsequently translates into compaction damage, are on average 16% higher for organic than for integrated crop farming. The same calculation without aggregation of the three soil layers results with an average difference of 17% for the top soil layer, 11% for the mid soil layer, and 24% for the bottom soil layer higher for organic than for integrated crop farming. This is visible in Figure 6.3. Figure 6.3 also shows for all of the soil layers a)-c) that differences between the crops within one production system are bigger than between the same crops produced in different mechanized production systems.

The differences are partly due to the number of machinery passes during one growing cycle. The average number of passes for the 24 organic and conventional crops considered in this study is 14.2 and 15, respectively. In four cases, the number is higher in organic production systems, in 14 cases lower. The differences in the number of passes result from different fertilizer and pesticide application regimes. Further differences result from the weight and the working widths of the kinds of machines used, especially in the application of farmyard manure in organic systems versus disc spreaders used for synthesized fertilizers and in the mechanical weeding in organic agriculture versus the application of pesticides in conventional farming. Note that we have used one machine specification (i.e. working width, machine weight, and tire pressure) for the same application, e.g. ploughing, in organic and conventional production.

To reduce compaction impact, an appropriate crop choice is more effective than a change between various mechanized production systems. The crops with the highest compaction impacts are potatoes and meadows in their first year. The most prevalent reason for both crops is the number of passes in the fields. Potato production depends highly on the weather conditions and can be intensive in crop protection (weed control and pest management). Moreover, the harvesting procedure needs heavy machines. This is because the harvest of the belowground growing tubers takes more energy (Williams et al., 2010), which is a direct measure for the size of the machines and the tractor power (Van Linden and Herman, 2014). The corrected tkm per ha for 81 crops are presented for the three soil layers in a Table in Appendix D, Section 11.9.

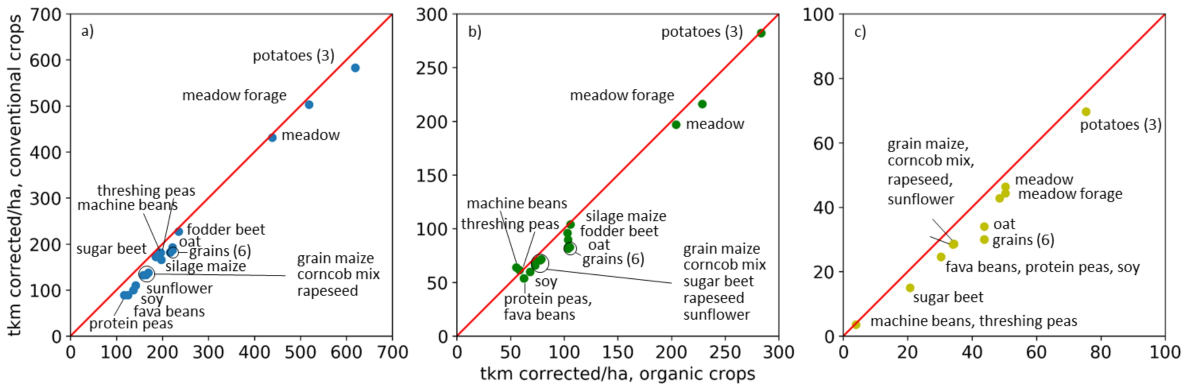

Figure 6.3 Comparison of pressure on soil for 24 organic (x-axis) and integrated (y-axis) crops for the three soil layers (a) top soil layer, b) mid soil layer, c) bottom soil layer) (the unit is corrected tkm per ha, which is proportional to the impact for each soil layer at a given site). The line of equality is depicted in red and the number in brackets is the amount of crops and production systems for overlaying dots.

6.3.2 LCIA CHARACTERIZATION FACTORS

The Characterization Factors are expressed in the unit “percent annual average yield loss per corrected tkm”. They depend on soil moisture and (in the case of the top soil layer) on clay content. The high geographical and depth-dependent variation of soil properties requires a high spatial resolution. Characterization Factors for the three soil layers (0-25 cm, 25-40 cm and > 40 cm depth) are provided as maps (Appendix D, Figure 11.1) and as GeoTIFF raster files (for 1 km resolution) on the ETH research collection server. Characterization Factors, aggregated to country and sub-country level, are also provided in the Appendix D, Section 11.9 (for methodological details see also Appendix D, p3).

Regions differ widely in susceptibility to soil compaction. The Characterization Factors for dry regions, as e.g. North Africa, South Africa, the Arabian Peninsula, the biggest part of Australia, are low. An exception is visible in the Nile Delta where the Characterization Factors are higher than in its surrounding. This is due to extensive irrigation practices. A similar situation is observed at the foot of the Himalaya Mountains in India.

The influence of the clay content of the soil is apparent when comparing the maps of Characterization Factors for topsoil and the maps of the Characterization Factors for bottom- and subsoil. This is especially pronounced in dry regions, e.g. on the Arabian Peninsula, where soil moisture is not responsible for the susceptibility to compaction, but the clay content. The reverse phenomena can be observed in Japan and South East Asia. Both have high soil moisture contents that are reflected in the Characterization Factors of the bottom and middle soil layer, whereas the Characterization Factors of the topsoil vary. The topsoil susceptibility of the Japanese islands is lower than the susceptibility of the island of South East Asia due to the lower soil clay content.

Regions with high clay content and high soil moisture and therefore high Characterization Factors in all soil layers are e.g. the South of Brazil (Santa Catarina, Parana and partly Rio Grande do Sul), the Caribbean Islands, Central Africa, and the Maharashtra district of India.

The Characterization Factor presented implies a long-term use of the land assessed as agricultural land. However, also if the land were abandoned, compaction impacts would continue showing as a loss of net primary production (NPP). Of course, the assessment would then need to respect recovery times and permanent impacts (see Figure 6.2).

6.3.3 LIFE CYCLE IMPACT

The impacts of compaction are illustrated with potato and wheat production for cropping systems in Figure 6.4. The same type of figure can be produced for all of the 81 crops with the information provided in the Appendix D and the calculation code written in Python™ on Github (link in Appendix D, p2). The geographical distribution of the impacts for both of the crops is very similar (triggered by the Characterization Factors and their dependence on soil characteristics). The difference of the impact between potato and wheat results from the different machine application during the production in one growing season. Potato cultivation needs more machinery inputs per ha because of the intensive pest management and because of the elaborate harvesting procedure of the belowground tubers (Williams et al., 2010). This is also shown in Lin et al. (2017), where the input of liters of diesel per ha and year is 46 and 104 for winter wheat and potatoes, respectively.

For time series of land use maps, e.g. when modeling dynamically changing crop rotations, the impacts can be aggregated in order to calculate the expected yield reductions. This analysis can go even further by incorporating the effect of changing soil moisture with climate prediction scenarios in order to find optimal crop rotations (land use scenarios).

Moreover, the impact can be assigned to compaction effects from different soil layers. This is shown in the Appendix D, Figure 11.2 for the example of potatoes. For regions with a soil moisture class (which is the average of yearly soil moisture) up to 2 (corresponding to a very dry and dry soil), 100% of the impact is assigned to the top soil layer compaction, resulting in a rather short-term effect. In this case, it is assumed that the soil can recover within 4 years if compacting treatments are stopped. When considering all locations with soil moisture class 3-5 (which corresponds to intermediate, moist and wet soil), 61% of the impact is assigned to top soil compaction, 12% to mid soil compaction, and 26% of the impact occurs due to bottom soil compaction. The latter is expected to be permanent.

The potential soil compaction impacts are shown for the whole world, although crop growth is not possible everywhere due to manifold factors and limiting environmental conditions, e.g. temperatures. In the Appendix D, Figure 11.3, the impact for the example of potato is shown on the current crop-specific growth area and on present total agricultural area, illustrating current compaction hotspots. However, compared to the status-quo presentation in the Appendix D, Figure 11.3, the global coverage of Figure 6.4 has the advantage that future sites of crop growth can also be taken into account in order to find out where it is not adequate to expand crop-growing areas with regard to compaction. Insights about potential compaction impacts are also useful when a transition is considered from manually managed small-scale farming system (without significant compaction impacts) to a more mechanized one.

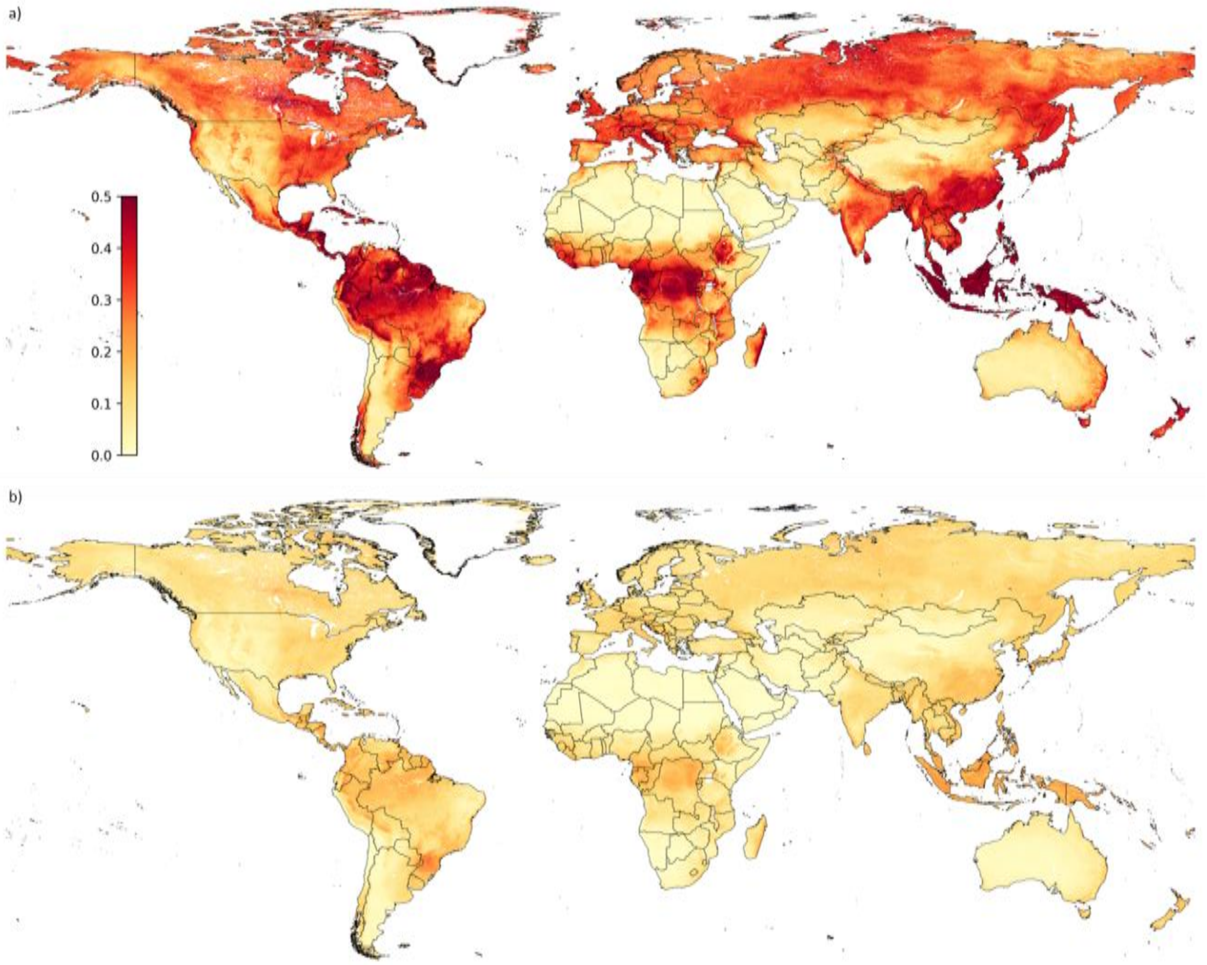

Figure 6.4 Comparison of impacts (average annual yield loss in % over 100 years) for potato (integrated, intensive) a) and winter wheat (integrated, intensive) b).

Yield losses due to soil compaction may remain unnoticed since yields underlie year-to-year variations. Farmers often try to compensate yield losses through fertilization or different cultivation practices (Hamza and Anderson, 2005; Nawaz et al., 2013), but by doing so they do not solve the underlying problem of compaction. There are different strategies either to prevent yield loss and other environmental impacts caused by soil compaction or to stimulate recovery in the top and mid soil layers through changed management strategies. Preventative management strategies are e.g. performing field work during low soil moisture periods, twin-tires and reduced tire-pressure for heavy machines (Hamza and Anderson, 2005), ploughing out of the furrow (Chamen et al., 2003), conservation tillage practices (as for example no-till management) (Farooq and Siddique, 2015), adapted crop rotation (ley pasture) (Radford et al., 2007) and controlled traffic farming using permanent traffic lanes (vs. random traffic farming) (Gasso et al., 2013). Furthermore, the enrichment of the soil with soil organic matter (SOM) improves its structure, which might help with mitigating compaction (Hamza and Anderson, 2005; Milà i Canals et al., 2007).

Recovery management strategies (always including preventative management strategies) include actions such as crop rotation change either to loosen compacted layers by a different soil management or by different rooting patterns or to grow crops which are less sensitive to compaction than others (Arvidsson and Hakansson, 2014). The results of recovering by subsoiling (tillage in deep soil layers) are moderate (Batey, 2009).

6.3.4 LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

In this study, one particular set of machinery data is used, corresponding to two Swiss production systems. Machinery type and use varies throughout the world and needs to be adapted to the specific conditions. This can either be done by individual data collection or the use of other existing databases, such as the database provided by KTBL (2011-2017). Furthermore, life cycle inventory databases such as ecoinvent (Ecoinvent, 2017) also include data on agricultural machinery. Most of the information needed as model input can be found in ecoinvent process descriptions or reports (Nemecek and Kägi, 2007). Along with the correction factors provided here and basic assumptions on tire pressure, this information can be translated into the Elementary Flow “corrected tkm per ha”, using the referenced Python code (link in Appendix D, p2). A direct integration of compaction pressure flows into the ecoinvent database, by generating the additional Elementary Flow “corrected tkm per ha” for existing processes, would shortcut the calculations for the user and facilitate the application of the compaction impact assessment method.

To calculate the Characterization Factors, the original model (Arvidsson and Hakansson, 1991) requires soil moisture data within a scale of 1 to 5 (1 = very dry, 2 = dry, 3 = intermediate, 4 = moist, 5 = wet) (Braunack, 1999). The subjective estimation of these soil moisture classes of the original method was replaced by using soil moisture proxy data from geospatial databases, as described in the method section. However, it was not possible to distinguish between soil moisture of various soil layers for the whole globe, as required by the selected original model (Arvidsson and Hakansson, 1991). Furthermore, soil moisture does not only vary horizontally and vertically, but also in time. Therefore, it is suggested to consider soil moisture data at monthly or daily resolution for calculation of temporally differentiated Characterization Factors in future work. Since crop production is also season-dependent and varies in time from North to South, inventory modelling should be temporally differentiated as well and combined with the corresponding Characterization Factors to increase the reliability of the results, as done for water consumption impacts (Pfister and Bayer, 2014).

The model is an empirical model, which could be seen as a limitation since it is a black box. However, the model has been proven to work for different conditions (Braunack et al., 2006). The model is suitable for annual crops grown in moldboard ploughing crop systems that is applied in approximately 90% of the global arable area. This is 100 % minus the estimated area under conservation tillage (7.4-11%), which has the tendency to rise (Derpsch et al., 2010; Kassam et al., 2014; Lal, 2013). Conservation tillage includes no-till systems where soils are not disturbed through tillage. An extension for conservation tillage systems and for perennial crops, as it was done by Braunack et al. (2006), would complete the possibilities for analyses, especially for the analysis of crop rotations with different tillage systems.

Soil compaction is not only a problem of crop growing agriculture. Soil compaction also occurs on pastures caused by grazing animals (Drewry et al., 2008), in forest harvesting, in recreation land use, and construction sites (Batey, 2009). The environmental assessment of a product or service requires including all stages of a life cycle. It is thus desirable to include other sources of soil compaction in the future.

Since GLASOD is the only global map on soil degradation that includes soil compaction, it is difficult to validate the results presented above. For single regions, more detailed and more up to date maps are available and presented for Europe in the Appendix D, Figure 11.4. A visual comparison of the Characterization Factors for top soil with the map reveals a good accordance of the regions associated with compaction risks.

6.4 CONCLUSION

This study offers a new method for LCA practitioners to include impact assessment of soil compaction into life cycle assessment of agricultural products. It enables the calculation of potential compaction impacts of crop rotation and cropland expansion scenarios. This type of analysis can be especially interesting in combination with climate change and future land-use scenarios, for example.

The comparison of the Elementary Flows of 24 pairs of organic and conventional crops revealed that the differences in impacts of mechanized production systems are small when compared with differences in impacts of different crops. Thus, to avoid compaction impacts, crop choice has the larger leverage than changing from one production method to another. Furthermore, an appropriate timing of the machinery application to favorable soil conditions (low soil moisture) and reducing the machinery load are effective measures to reduce compaction impacts.

The structures of the soils vary widely. In this study, the global Characterization Factors for the impact of soil compaction were based on spatially highly resolved soil clay data (250 m, aggregated to 1 km) and soil moisture data at a resolution of 1 km. The Characterization Factors for dry regions are low, except in regions where widespread irrigation is practiced. The influence of the clay content of a soil is reflected in the Characterization Factors for the topsoil. Dry sites with enhanced clay content have higher values for the Characterization Factors in the topsoil than for the Characterization Factors in the middle and bottom soil. The highest Characterization Factors for all soil layers are observed in regions with high soil moisture and high values of clay content. In those regions, annual yield losses averaged over 100 years can amount up to 0.5 % (cumulated over 100 y this corresponds to a one-time loss of 50 % of the present yield), and, hence, at those locations compaction represents a substantial risk to agricultural production.

The geographical distribution of the Characterization Factors is clearly visible in the impact of different crop productions under the assumption that the Elementary Flow for one crop is the same worldwide. Around one quarter of the impact in regions with soil moisture classes 3-5 (that corresponds to intermediate, moist and wet soils) is attributed to compaction impacts resulting from bottom soil compactions, which are expected to be permanent. Repeated crop growing under unfavorable conditions can accumulate the compaction impact and harm the production of agricultural commodities for a long time.

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CHAPTER 7

CONCLUSIONS AND OUTLOOK

7.1 EMBEDDING THE THESIS INTO THE CONTEXT OF "FULL LCA" OF AGRICULTURAL PRODUCTS

Comprehensive assessment tools are needed to analyze the design of the sustainable future food systems. This thesis contributes to the advancement of Life Cycle Assessment, representing one of the major tools for assessing the environmental sustainability of agricultural systems. The focus was placed on Life Cycle Inventories for agricultural products and the development of methodologies, which allow an assessment of the impacts from agricultural production.

The thesis started out with a review on Life Cycle Assessments of agricultural products (Chapter 2). The comparison of products and even more the comparison of farming systems require consistent and comprehensive datasets including production and processing stages. Another result of the review comparing LCAs of organic and conventional products revealed the need to enlarge the available Life Cycle Impact Assessment to the land use impact on soil quality. Both aspects are also highlighted in two recent reviews about agricultural LCAs (Notarnicola, Sala et al. 2017, Dijkman, Basset-Mens et al. 2018).

In this thesis no "full LCA", depicted in Figure 7.1, was performed. However, the investigation into specific topics allowed filling some of the gaps revealed in Chapter 2: In Chapter 3 & Chapter 4 we enlarged the LCI for food items that are frequently applied on solely two stages to four stages, including 1) transportation of input to the farm, 2) cultivation, 3) processing and 4) transports. Wastes on the field (stage 6) waste management) are included in the agricultural production stage. The inventories were adapted to different sourcing countries. Unlike those in other studies we assessed climate change and water use impacts and the results revealed that there are conflicts of interests in some cases, while the results of both impact categories were in accordance in other cases. As a result of Chapters 2-4 and based on the existing literature, a framework on the assessment of the land use impact on soil quality was developed in Chapter 5. The application of one pathway from the framework is operationalized and shown in Chapter 6.

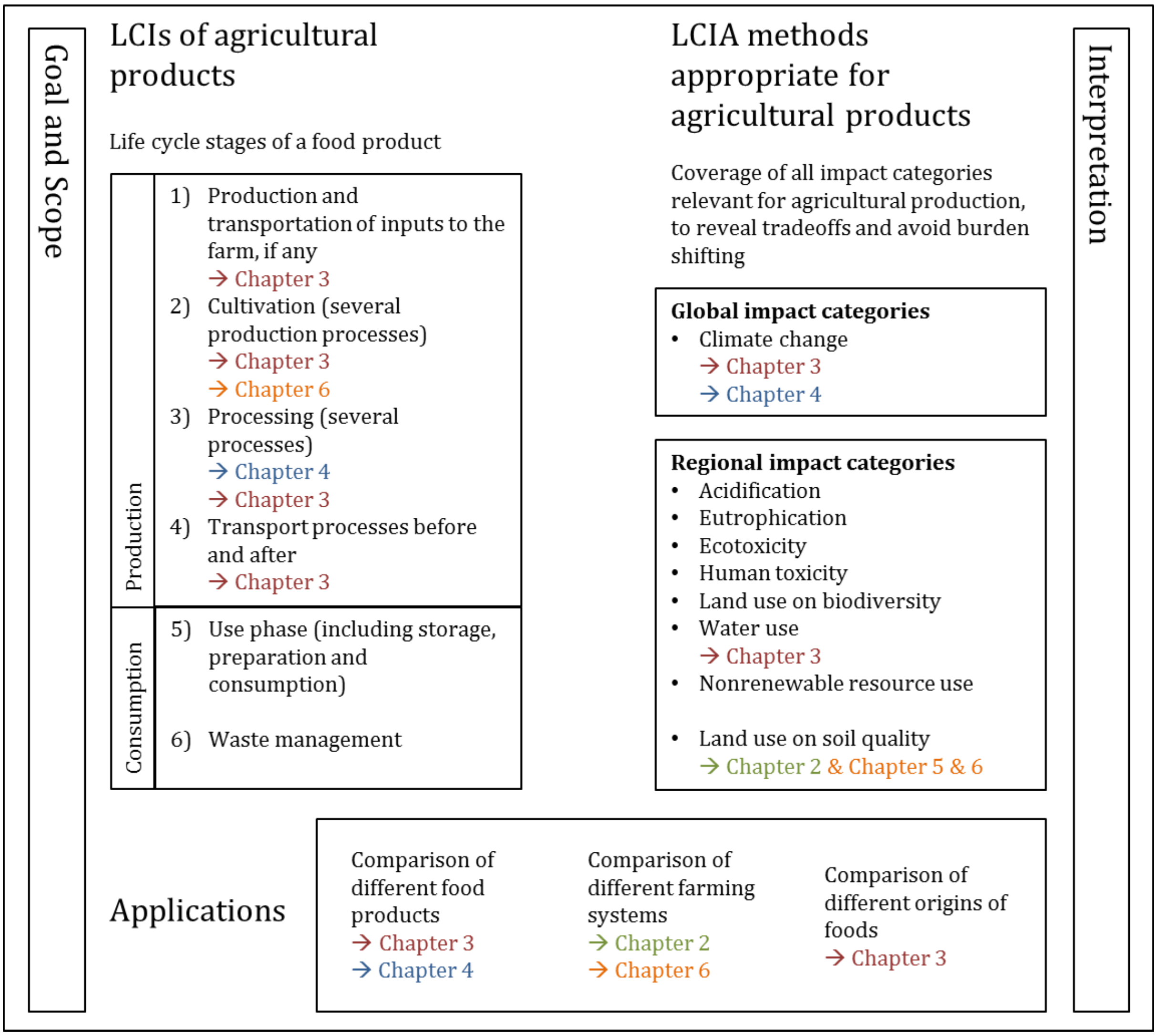

Figure 7.1: Schematic overview of the topics investigated in this thesis and embedding into the "full LCA" scope of agricultural products.

7.2 CONCLUSIONS AND DISCUSSION OF THE THESIS

The design of future food systems needs powerful environmental assessment tools to avoid impacts to the natural environment as far as possible and meet the Sustainable Development Goals. Life Cycle Assessment strives for a comprehensive evaluation of systems. To this end, appropriate models and data are needed. The thesis contributes to the advancement of LCA for agricultural production. First, LCIs for several fruits and vegetables are set up in a consistent and comprehensive way. Another way to provide inventory data is shown by providing a tool for the generation of food processing datasets. The review of existing LCA studies comparing the impacts of organic and conventional products emphasize the necessity of applying adequate models (e.g. to satisfy the different nutrient flows) and the use of comprehensive impact assessment methods to avoid burden shifting. This is of special interest when analyzing different production systems for future food production. We were able to broaden the available methods by proposing a framework for the impact of land use on soil quality, resulting in the loss of biotic production potential. The operationalization for one of the impact pathways, the impact of soil compaction due to agricultural production, is presented. This method is the first method to assess compaction impacts in LCA on a global level and being able to differentiate between farming systems.

The datasets established in Chapter 3 for the 34 fruits and vegetables cover the major part of a Swiss retailer's fruit and vegetable assortment. Processes belonging to the production stages, i.e. land use, growth of seedlings, application of fertilizers and pesticides, mulch film use and disposal, flame treatment, farm machinery use, irrigation, electricity and heating in greenhouses, emissions of fertilizer, transportation processes for the inputs to the farm, including seedling transport and the distribution to the retailer including refrigeration energy, storage and packaging by the consumer in the store, are covered. This level of detail in LCI was only available for case studies on the production of single food items at the time of conducting the study. Chapter 3 represented a pioneer inventory effort, which was followed by further initiatives by other authors afterwards: larger agricultural datasets became available and are described in Chapter 1.4.1. The LCI represented a data source for many other publications. For example the results of Chapter 3 were used in consumer behavior studies of other authors, where the perceptions of consumers concerning the environmental impact of food products were studied (Lazzarini, Visschers et al. 2017, Shi, Visschers et al. 2018). Furthermore the results were used in studies exploring the field of environmentally sound and healthy diets as e.g. done by Walker, Gibney et al. (2018). For many studies, parts of the datasets (e.g. seedlings in Markussen, Kulak et al. (2014) or transports in Beretta, Stucki et al. (2017)) or the whole inventory for single products served as a basis (Saner, Beretta et al. 2016, Sturtewagen, De Soete et al. 2016). The result can also be compared to other studies which were conducted independently. For example, for the case of asparagus, two studies found that the results of Chapter 3 were in good accordance with their own results (Soode, Lampert et al. 2015, Schwarz, Schuster et al. 2016). Bartl, Verones et al. (2012) studied the agricultural production of the Peruvian asparagus using LCA and found a big difference in the airborne ammonia emissions compared to the ones applied in Chapter 3. The reason is found in the kind of fertilizer applied in both studies. The Life Cycle Inventory in Bartl, Verones et al. (2012) was made on-site and is therefore much more specific. The findings emphasize the importance of regional LCIs, similar as the findings of the review in Chapter 2, which found that differences of the nitrogen fluxes in the LCIs of different farming systems were not always taken into account. The same is the case for soil quality impacts in general, which may vary between different production systems.

With the increase in processed foods and new foods (Augustin, Riley et al. 2016), flexible tools to assess the impacts of the processing stages are required. The toolkit in Chapter 4 allows, e.g. to the food industry, to optimize production processes from an environmental perspective. It provides an estimation of energy demand of operations such as dehydration, evaporation, or pasteurization and serves as a basis to perform LCA studies. The estimations on the unit-process level can be combined according to recipes, as illustrated for frozen spinach where the agricultural production part of the LCA came from Chapter 3. The toolkit is furthermore used in recent studies like for the assessment of a typical Belgian meal (Sturtewagen, De Soete et al. 2016), the design of school lunches (Ribal, Fenollosa et al. 2016) or the gelatin extraction from tilapia residues (Sampaio, de Sá M. de Sousa Filho et al. 2017). In contrary to other food processing LCA, the toolkit has broader view for different operations than case studies that have focused on single products (Thoma, Ellsworth et al. 2018).

An improvement of LCAs of food systems does not only rely on high-quality LCI, but also on comprehensive LCIA methods that strive for a complete set of impact categories. The framework, introduced in Chapter 5, assesses the biotic production potential loss due to different land degradation processes caused by agricultural production. This loss of biotic production potential represents an impact on ecosystem services of soils. Other approaches like Bos, Horn et al. (2016) and Oberholzer, Knuchel et al. (2012) are data intensive. The multi-level system proposed in this thesis, with background databases containing all relevant information, facilitates the use for LCA practitioners. The structure still leaves the possibility to enhance the quality with specific data that is adapted to local practices. Important and partly new elements of the framework are the integration of different agricultural practices, the inclusion of all relevant impact pathways and the provision of globally applicable characterization factors in high spatial resolution in order to take the soils spatial heterogeneity into consideration.

The successful operationalization for the impact pathway of soil compaction in Chapter 6 provides characterization factors on a high level of spatial resolution (1x1 km). The results comparing 24 crops, cultivated in organic or conventional method, showed small differences in impacts between the different mechanized farming systems. This is in accordance to the findings that are presented by Nemecek, Dubois et al. (2011). The global characterization factors are highest in regions, where soil moisture and clay content are high. In such regions compaction impacts, induced by one year potato cultivation, can be substantial, amounting up to an average 0.5% annual yield loss of a current yield for the next 100 years. The characterization factors are lower in dry regions, except where widespread irrigation is practiced. The average world potato yield from 2007 to 2016 was 18.8 t/ha (FAOSTAT 2017). The average world yield loss due to compaction induced by one year of potato growing is 0.25% per year (during 100 years). Supposing that the potato growing area remains constant and potato growing always takes place in the same fields, it can be assumed that, cumulated over the next 100 years, around 5t of potatoes are lost on every ha planted potatoes due to compaction impacts.

In our model we assumed that the soil system belonged to the ecosphere (the natural environment). This was part of controversial discussions, because sometimes the "productive part of the soil" is related to the technosphere (Notarnicola, Sala et al. 2017). In this thesis, we argue that long-term soil productivity can be seen as a natural resource, essential for human wellbeing. Furthermore, degraded soil will not harbor the same biodiversity as non-degraded soil, when land is converted back to a natural state. For these reasons, we argue that soil productivity needs to be assessed in LCA.

7.3 SCIENTIFIC RELEVANCE

In this dissertation we provide large Life Cycle Inventory datasets. The setup of such data sets is shown by investigating LCIs for several fruits and vegetables in a consistent and comprehensive way. It served as a model dataset in order to further develop datasets for fruit and vegetables and also other agricultural products. Moreover, we provided a generic tool for the generation of food processing datasets, as a function of the recipe and further process information. A great variety of processed food products can be evaluated using this tool, if basic information of production processes is available. Both approaches can be combined and used to derive a multitude of food inventories. This is a major scientific achievement in the field of agricultural LCA, which until the start of this thesis suffered from severe data gaps.

The recommendations for the assessment phase that were identified in Chapter 2 were taken up in this dissertation and a framework for the impact assessment of land use on soil degradation was developed. This framework proposes to distinguish different agricultural production methods on the level of production processes, which is new. The impacts are assessed in terms of "long-term yield loss" resulting from four degradation impacts that are aggregated in order to estimate the overall impact on the biotic production potential. This was done, for the first time, in this dissertation by operationalizing one impact pathway of the proposed framework. Global characterization factors for the impact of soil compaction on the yield are derived. They are made available on a resolution of 1x1 km and can be applied together with the elementary flows provided for 81 crops from different production systems and corresponding machinery specifications. This is the first method that allows for a quantitative assessment of long-term productivity decline due to soil degradation in LCA, which is increasingly important in the context of growing food demand. The method it is made available to the scientific community, providing the source code and extensive data to run the model.

7.4 PRACTICAL RELEVANCE

The work in this thesis contributes to various practical implementations of Life Cycle Assessment of agricultural products. These include new databases and improvements in Life Cycle Inventory; decision support for retailer's purchasing decision, consumer communication and sensitization.

The datasets developed in Chapter 3 were integrated into the Life Cycle Inventory database of Ecoinvent version 3.0 (Ecoinvent 2013, Wernet, Bauer et al. 2016), after small adaptations in fertilizer and pesticide emissions according to Nemececk and Schnetzer (2011), making them available to LCA practitioners. Ecoinvent is used by more than 3000 organizations worldwide providing well documented process data for thousands of products (Ecoinvent 2017). As a consequence, the datasets have been used in multiple LCA studies.

One recent example of a practical application of the inventory and assessment results found in Chapter 3 is an app called Idemat, currently available for iOs and Android systems (Vogtländer and Meursing 2015). The app is a sustainability inspired material selection app that is meant for designers to use sustainable material for their product and for education. The Idemat app intends to bring LCA results closer to the start of a design process. It features eco-costs (Vogtländer, Brezet et al. 2001) and carbon footprint of a product with three different waste management scenarios. The use of IdematLightLCA, a second version of the Idemat tool includes an extra option that makes it possible to calculate a simple LCA.

Coop, one of the two major retailers in Switzerland, uses results from Chapter 3 to environmentally improve the supply chain. Within the framework of this study a simple Excel-based tool is built for the purchasers in order to find out where the environmentally best option was to buy the commodities for resale. In the communications "Actions Not Words" the environmental friendly acts, such as internally used LCA results for the improvement of supply chains, are presented (Coop Group 2013). For example, the LCA results of asparagus production supported the decision to restrain from special offers for green asparagus that was transported by airplane, which subsequently reduced the amount of asparagus flown in. Instead, a new asparagus plantation site in Morocco was supported including training of the producers in sustainable water use. The emissions generated by the air transport of the remaining products are compensated by funding compensation projects with WWF and myclimte, a Swiss non-profit organization. Consumer's sensitization was done via articles in customer magazines, and the LCA results were portrayed in an easy to read manner and spread in other newspapers and magazines as for example in Minder (2012) and Gähwiler (2015).

Food processing data is often difficult to get, e.g. due to data confidentiality. Chapter 4 provides a tool to LCA practitioners to generically estimate inventory data for food processing. This tool has already been applied in industrial case studies (Walker, Beretta et al. 2017), and is available for practical use.

Decisions by farmers, government and policy makers need basic information about the impacts of agricultural management practices. Chapter 6 provides an impact assessment methodology to calculate the soil compaction impacts due to agricultural practices. The method is applicable on global and regional scale. The current application in Chapter 6 is done at global scale and can inform policy makers about priority crops and geographical areas. The method could also be used in a screening assessment on regional level in order to identify environmental hotspots and to provide incentives for a sustainable production.

Scenarios about future sustainable food production need impact assessment methods that cover all relevant impact categories, including impacts of land use on soil quality (see Chapter 2). Once operationalized for all impact pathways, the framework presented in Chapter 5 will enable to recognize tradeoffs and possibly avoid burden shifting. This could considerably enhance the quality and sustainability of future agricultural solutions.

7.5 CRITICAL APPRAISAL AND OUTLOOK

The review in Chapter 2 is based on 34 LCA studies comparing organic and conventional production systems. The number of 34 studies could be enlarged in order to better support the analysis. Furthermore, the focus was set on the analysis of the N-fluxes, which revealed a great improvement potential. The N-characteristics (e.g. content and physicochemical properties) of fertilizers should be differentiated to account for the different degradation and absorption pathways. This is in particular important for organic fertilizers. The N-fluxes specific to different farming systems (e.g. the nitrogen emission calculation from different animal feeding systems or N_2O emission calculations from organic fertilizers (Meier, Schader et al. 2012)) are not yet completely understood and should be included in the modeling in future research. The review could be extended with a discussion of differences between organic and conventional agriculture other than nutrients, which were not the focus of Chapter 2 but are also relevant.

Life Cycle Inventories of agricultural products can vary widely because of the heterogeneity in production systems. The accuracy of inventory data depends on the focus of a study, whether it is a case study for one specific case or a comprehensive study for food supply chains, which was the case in Chapter 3. While this study accounted for spatial variability between various countries of origin and, to a certain extent, production systems (e.g. between heated and non-heated greenhouse production and open field), a further improvement potential is seen in considering variability and uncertainty for all inventory parts. For example, a recent study about “packaging for fresh produce in the cold chain” (Defraeye, Cronjé et al. 2015) showed that the energy consumption of a refrigerated container depends on the type of cargo and packaging. Such variabilities should be added to the inventory set up in this thesis using e.g. information about spatiotemporal variation of cooling demand (Ambaw, Bessemans et al. 2016) or using the toolbox of Chapter 4.2.6 and 4.2.8 about precooling and refrigerated storage which was only available after the time of writing Chapter 3. Further research should investigate the variability in LCA results (Djekic, Sanjuán et al. 2018).

The LCI of the fruit and vegetable production in Chapter 3 include many production processes that are compiled in a consistent way for all of the products. The advantage of such inventories is the possibility to compare the results and to apply it for the analysis of the overall impact of fruit and vegetable consumption. However, the inventory analysis of Chapter 3 and Chapter 4 omits several processes, which were assumed to be of minor relevance, but should be assessed for relevance and the sake of completeness in future research. These are, for example, the leaking of refrigerants, drip irrigation pipes and the disposal of the remaining pesticides. Investigation on the impact of “natural” pesticides used in organic (and sometimes conventional) agriculture is necessary when it comes to the comparison between farming systems, but have only rarely been assessed. The relevance to include capital goods like greenhouses has been demonstrated by Torrellas, Antón et al. (2012), where different greenhouse systems are compared. The lower the expenditure for heating the horticultural production the higher is the relative contribution of the infrastructure to the environmental impact. The contribution of the greenhouse structure in unheated tomato production amounts to 30 to 48 % depending on the impact category assessed (Torrellas, Anton et al. 2012).

One important aspect, which was only partly (losses on the field) integrated in Chapter 3, is the consideration of food wastes along the value chain. Thoma, Ellsworth et al. (2018) according to other publications, attribute 70-90 % of the impact in a full supply chain to the primary production phase and 10-20 % to the processing and manufacturing stage. Food waste shares of the different stages have been published for Switzerland (Beretta, Stoessel et al. 2013), but an integration of these results into the value-chain analysis of food is still missing. This is of particular relevance in the consumption stage in industrialized countries, which has been omitted in the present thesis, but is responsible for about 50 % of the climate change impact of avoidable food waste (Beretta, Stucki et al. 2017).

Full operationalization of the proposed framework on soil quality impacts in Chapter 5 remains an object of future research. The framework proposes to encompass four aspects of soil degradation in an impact assessment method for land use impact on soil quality. The validity of the choice of these impact pathways needs to be verified, based on knowledge from soil science. The aggregation of the four impact pathways of soil degradation was based on the concept of "response addition", borrowed from the field of mixture toxicity. While this is a simplified approach to correct for double counting of multiple independently acting effects, the interaction of various impacts is not completely understood and needs to be investigated further. In particular, we could encounter opposite effects from the various impact pathways, and a solution needs to be found of how to handle those. We suggested the aggregation of the impacts of the different pathways into a common impact category, measured in terms of yield loss per damage. Thus, the reduction of the soil productivity is expressed in a loss of biotic production potential. Soil productivity can be seen as an ecosystem service or "natural resources" following the definition of the UNEP/SETAC Life Cycle Initiative that "Natural resources are material and non-material assets occurring in nature that are at some point in time deemed useful for humans" (Sonderegger, Dewulf et al. 2017). The loss of production capacity can also affect human health (malnutrition) and ecosystem quality (less productive soils will harbor a different biodiversity than productive soils), and future research should embed these effects of soil degradation into the LCIA framework.

Chapter 6 serves as an illustrating example assessing soil degradation in different farming systems and on a high spatial resolution. It ideally serves as an example for the other impact pathways, which still need to be operationalized.

The model used in Chapter 6 is an empirical model. It was developed in the 1990s using field studies that are conducted in Sweden and the United States. It estimates the effects of compaction on the yield in tillage systems that include moldboard ploughing. The model calculates a driving distance on one hectare considering the working width of the machine and the extra traffic. The distance is supplemented with the load of the axles and the corresponding tire pressures, resulting in a factor called "corrected tonne-kilometer (tkm)". Soil compaction is controlled by the type and intensity of the mechanical load as external factors (Ledermüller, Lorenz et al. 2018). The axle load is a decisive parameter for the impact to deeper soil layers, whereas the tire pressure is mainly important for the topsoil layer (Lamandé, Greve et al. 2018, Lamandé and Schjønning 2018). The influence of the axle load and the tire pressure are varied using threshold values depending on which depth of the soil the compaction impact occurs, and they were calculated differently for earth works and for other production steps. The calculation of the characterization factors, that translate the corrected tkm into a corresponding "yield loss" are depending on the site with its specific clay content and soil moisture. Also for soil moisture a threshold value, depending on the soil layer, is chosen. The losses are given in "% yield loss" of a current reference yield prior to the compaction event.

According to Lipiec, Arvidsson et al. (2003) the applicability of the model is not restricted to Sweden, while the application to the whole planet, as done in Chapter 6, may be discussed. A mechanistic model would eliminate such disadvantages, but does not exist yet. However, the original author of the empirical model wrote in a personal communication (Arvidsson 2013), that "in fact the longer I work the more difficult I think it is to link physical properties and plant growth. I think for sure that the basic concepts of the model can be used also in other parts of the world, preferably with local data", which is, what we have done. The simplifications that had to be accepted in order to achieve the aim of modeling the impact of agricultural processes on soil degradation on a global level are described in the following.

For example, soil texture was characterized by only one parameter, soil clay content, although it is known nowadays that the physical stability of a soil and thus the ability to resist against soil compaction depends on the organic matter content too. Keller and Håkansson (2010) and Alaoui, Rogger et al. (2018) for example describe that soils with a moderate to high clay and organic matter content tend to have a more stable soil structure. Compacted sandy soils leave a draining soil structure because of the particle size, but form impenetrable structures that prevent roots from growing into soil depth (Hester and Harrison 2012). Strong attempts should be made in the future to include soil organic matter into the compaction model, especially on topsoil level. One recent publication describes the effect on crop growth connecting a soil compaction model with a model that indicates the least limiting water range (depending on soil carbon, amongst others) (Keller, da Silva et al. 2015). However, this model needs a wide range of specific soil properties that are not available for modeling at global scale and according to the authors it needs further research to include the crop performance.

Soil moisture content is another soil property that is highly variable on both the spatial and temporal scale. Our characterization factors are modelled with one average yearly soil moisture value that only varies in space. Due to limited soil-moisture data availability on a global level, we were not able to fulfil the original models requirement to specify soil-depth specific soil moisture. In the original model, soil moisture values are distinguished for topsoil and subsoil layers (including mid soil and bottom soil layers). Soil moisture is in particular relevant for soil compaction. Since the required data resolution in space and depth is not available yet it might be useful to date to integrate a soil moisture probability distribution in our model.

The applied spatial resolution of 1x1 km for both, the soil clay content and the soil moisture content is unusually fine for LCA, but too coarse to cover the small-scale variability in clay content and soil moisture encountered at many sites. Because averages were used for clay content and soil moisture contents, extreme compaction impacts can be underestimated.

Another simplification in Chapter 6 is the machinery dataset that corresponded to an average Swiss production, while the geographical variation of machinery type used throughout the world should ideally be taken into account. One possibility to do so could be to integrate the agricultural machine intensity per country. In the world soil resources report, FAO and ITPS (2015) present a map indicating soil compaction risk derived from intensity of tractor use in crop land and from livestock density in grasslands. This map, together with the machine intensity data derived from (FAOSTAT 2017), could serve as a basis for the variability of global machine intensities and be integrated into the model.

In addition to the critical review of the input data for the soil compaction impact modelling, the model also uses simplifications. It assumes additive compaction effects, which is valuable for repetitive short-term loadings of the soil, but only until mechanical equilibrium conditions are reached. The model calculates a continuous impact that does not consider a stress state where a soil starts to mechanically fail. This stress state is defined by the precompression stress, which is depending on the loading history that is not considered in the model.

For the Life Cycle Impact modeling in this thesis we have chosen to integrate the impact of the topsoil as well as the impact on the subsoil. The model allows distinguishing the impacts on the different layers. Topsoil compaction effects are reversible within short time (in the model the recovery time was assumed to be four years for topsoil compaction effects and 10 years for middle soil compaction effects). The recovery in the topsoil layer depends on the severity of compaction, the soil type and the climatic conditions. It can be stimulated by mechanical intervention (Hester and Harrison 2012). By contrast, subsoil compaction effects are believed to be almost irreversible (Obour, Schjønning et al. 2017, Lamandé, Greve et al. 2018, Schjønning and Lamandé 2018). Some prevention and recovery management strategies are briefly presented in Chapter 6.3.3. The topsoil compaction impact is included in the Life Cycle Impact Assessment because it results in a yield loss that is of a sizable amount. Compactive stress is often repeated by continuous agricultural management. In this case even topsoil impact can be regarded as long-term.

The importance of using appropriate input data for the calculation of the elementary flow is described above and also seen in Figure 6.3, where the corrected tkm for different crops are depicted. It is known from the literature (Gemtos, Goulas et al. 2000, Arvidsson, Bölenius et al. 2012) that sugar beet production often has a high soil compaction impact. This is not reflected in the figure because the input parameters chosen were too low. The impact of sugar beet production can partly be explained by the heavy axle loads that are used. This leads to the question about how reliable are the thresholds used for the weight corrections in the calculation of the elementary flow. Is this correction adequate for the use of generally much heavier machinery that is in operation nowadays or does this correction underestimate the impact on the subsoil due to the exceedance of the soil strength? Since the original data did not include such heavy machinery, the empirical model may not quantify compaction risks correctly for these cases. The example of sugar beet production also highlights the necessity to vary the soil moisture on the temporal scale because harvesting time often takes place during colder and wetter seasons, which leads to a higher compaction risk.

Finally, our methods are most valuable when they are used in an everyday life of an LCA practitioner. Therefore the impact category assessing land use on soil quality (or to date the impact of soil compaction in agricultural production) should be integrated into standard LCA software. As these impacts are varying in space and time, an adaptation of LCA softwares for a dynamic modeling could improve the accuracy and generally facilitate the use of all regional impact categories, whenever LCIA methods are available.

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APPENDIX A

SUPPLEMENTARY MATERIAL: ENVIRONMENTAL IMPACTS OF ORGANIC AND CONVENTIONAL AGRICULTURAL PRODUCTS – ARE THE DIFFERENCES CAPTURED BY LIFE CYCLE ASSESSMENT

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This Appendix is a reprint of the ‘Supplementary Material’ of the following published article: ***Matthias S. Meier, Franziska Stoessel, Niels Jungbluth, Ronnie Juraske, Christian Schader, Matthias Stolze. 2015. Environmental impacts of organic and conventional agricultural products – Are the differences captured by life cycle assessment. Journal of Environmental Management 149, 193-208.*** *The content is reproduced “as is”, however the formatting was changed and references have been updated.*

Cederberg & Flysjö 2004 Sweden

Data source: primary data assessed on 6 organic and 9 conventional farms;ingredients concentrate feed: region specific statistical data, organic grain yiels estimated to be 60% of conventional yields, organic horse bean yields estimated to be 80% of conventional yields, organic oilseed rape yields estimated to be 60% of conventional yields, organic soybean yield estimated to be 70% of conventional yields, organic sugar beet yields estimated to be 80% of conventional

Milk Sample 1 (Cederberg & Flysjö 2004) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not applicable
Impact category	abiotic resource use	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1991)
Impact per product unit conventional	2.59 MJ / kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	2.1 MJ / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	not applicable
Impact per area and year conventional	16819 MJ / ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	LCI only
Impact per area and year conventional	7167 MJ / ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	-19%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	P < 0.05	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	not applicable
Relative difference per area and year (basis = conv)	-57%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	none
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic (90% milk / 10% meat)		

Milk Sample 2 (Cederberg & Flysjö 2004) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	land use	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1991)
Impact per product unit conventional	1.54 m2*a / kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	2.93 m2*a / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	not applicable
Impact per area and year conventional	- m2*a / ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	LCI only
Impact per area and year conventional	- m2*a / ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	90%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	P < 0.001	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	not applicable
Relative difference per area and year (basis = conv)	-	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	none
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic (90% milk / 10% meat)		

Milk Sample 3 (Cederberg & Flysjö 2004) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not applicable
Impact category	GWP	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1991)
Impact per product unit conventional	896.22 CO2-equ. / kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	938.49 CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (1997)
Impact per area and year conventional	5820053 CO2-equ. / ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	LCI only
Impact per area and year conventional	3203066 CO2-equ. / ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	methane conversion factor from manure management from Danish studies: 10%
Relative difference per product unit (basis = conv)	5%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	n.s.	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	not applicable
Relative difference per area and year (basis = conv)	-45%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	some thoughts on the methane conversion factor for slurry (page 43)
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic (90% milk / 10% meat)		

Milk Sample 4 (Cederberg & Flysjö 2004) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not applicable
Impact category	pesticide use	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1991)
Impact per product unit conventional	71.3 mg AI / kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	7.8 mg AI / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	not applicable
Impact per area and year conventional	463022 mg AI / ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	LCI only
Impact per area and year conventional	26621 mg AI / ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	-89%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	P < 0.001	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	not applicable
Relative difference per area and year (basis = conv)	-94%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	none
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic (90% milk / 10% meat)		

Milk Sample 5 (Cederberg & Flysjö 2004) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not applicable
Impact category	eutrophication	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1991)
Impact per product unit conventional	3.72 kg PO43--equ / kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	5.03 kg PO43--equ / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	not applicable
Impact per area and year conventional	24171 kg PO43--equ / ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	LCI only
Impact per area and year conventional	17167 kg PO43--equ / ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	35%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	n.s.	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	not applicable
Relative difference per area and year (basis = conv)	-29%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	none
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic (90% milk / 10% meat)		

Milk Sample 6 (Cederberg & Flysjö 2004) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not applicable
Impact category	eutrophication	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1991)
Impact per product unit conventional	24170.67 kg PO43--equ / ha	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	17167.39 kg PO43--equ / ha	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	not applicable
Impact per area and year conventional	156964318 kg PO43--equ / ha	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	LCI only
Impact per area and year conventional	58592302 kg PO43--equ / ha	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	-29%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	n.s.	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	not applicable
Relative difference per area and year (basis = conv)	-63%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	none
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic (90% milk / 10% meat)		

Milk Sample 7 (Cederberg & Flysjö 2004) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not applicable
Impact category	acidification	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1991)
Impact per product unit conventional	0.01023 kg SO2-equ./kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.01163 kg SO2-equ./kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	not applicable
Impact per area and year conventional	66 kg SO2-equ./ ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	LCI only
Impact per area and year conventional	40 kg SO2-equ./ ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	14%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	NH3 and NOx: n.s.SO2: P < 0.001	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	not applicable
Relative difference per area and year (basis = conv)	-40%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	none
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic (90% milk / 10% meat)		

Cederberg & Mattsson 2000 Sweden

Data source: primary data assessed on 1 organic and 1 conventional farm

Milk Sample 8 (Cederberg & Mattsson 2000) Remark: -

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	energy demand	**Productivity conventional**	5195 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Emission data from Swedish EPA: 155 kg CH4/cow (conventional), 12% higher emissions for organic cows
Impact per product unit conventional	3.55 MJ / kg ECM	**Productivity organic**	2887 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	2.511 MJ / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-44%	**Calculation basis for N2O-emissions from soils and manure storag**	?
Impact per area and year conventional	18442 MJ / ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	Cumulative energy demand
Impact per area and year conventional	7249 MJ / ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	-
Relative difference per product unit (basis = conv)	-29%	**Delivered milk conventional**	7813 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	7127 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-61%	**Relative difference yield - delivered milk (basis = conv)**	-9%	**Uncertainty analysis on results**	yes
Significant difference (area and year)?	no testing	**Allocation rule for milk**	biological (according energy and protein requirements: 85% to milk / 15% to meat)		

Milk Sample 9 (Cederberg & Mattsson 2000) Remark: -

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	land use	**Productivity conventional**	5195 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Emission data from Swedish EPA: 155 kg CH4/cow (conventional), 12% higher emissions for organic cows
Impact per product unit conventional	1.925 m2 / kg ECM	**Productivity organic**	2887 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	3.464 m2 / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-44%	**Calculation basis for N2O-emissions from soils and manure storag**	?
Impact per area and year conventional	- m2 / ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	LCI flow
Impact per area and year conventional	- m2 / ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	-
Relative difference per product unit (basis = conv)	80%	**Delivered milk conventional**	7813 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	7127 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-	**Relative difference yield - delivered milk (basis = conv)**	-9%	**Uncertainty analysis on results**	yes
Significant difference (area and year)?	no testing	**Allocation rule for milk**	biological (according energy and protein requirements: 85% to milk / 15% to meat)		

Milk Sample 10 (Cederberg & Mattsson 2000) Remark: -

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	pesticide use	**Productivity conventional**	5195 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Emission data from Swedish EPA: 155 kg CH4/cow (conventional), 12% higher emissions for organic cows
Impact per product unit conventional	0.118 g / kg ECM	**Productivity organic**	2887 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.0108 g / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-44%	**Calculation basis for N2O-emissions from soils and manure storag**	?
Impact per area and year conventional	613 g / ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	LCI flow
Impact per area and year conventional	31 g / ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	-
Relative difference per product unit (basis = conv)	-91%	**Delivered milk conventional**	7813 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	7127 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-95%	**Relative difference yield - delivered milk (basis = conv)**	-9%	**Uncertainty analysis on results**	yes
Significant difference (area and year)?	no testing	**Allocation rule for milk**	biological (according energy and protein requirements: 85% to milk / 15% to meat)		

Milk Sample 11 (Cederberg & Mattsson 2000) Remark: -

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	GWP	**Productivity conventional**	5195 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Emission data from Swedish EPA: 155 kg CH4/cow (conventional), 12% higher emissions for organic cows
Impact per product unit conventional	1.1 kg CO2-equ. / kg ECM	**Productivity organic**	2887 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.95 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-44%	**Calculation basis for N2O-emissions from soils and manure storag**	?
Impact per area and year conventional	5715 kg CO2-equ. / ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	IPCC (1996) GWP 100
Impact per area and year conventional	2743 kg CO2-equ. / ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	yes, for CH4
Relative difference per product unit (basis = conv)	-14%	**Delivered milk conventional**	7813 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	7127 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-52%	**Relative difference yield - delivered milk (basis = conv)**	-9%	**Uncertainty analysis on results**	yes
Significant difference (area and year)?	no testing	**Allocation rule for milk**	biological (according energy and protein requirements: 85% to milk / 15% to meat)		

Milk Sample 12 (Cederberg & Mattsson 2000) Remark: -

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	acidification	**Productivity conventional**	5195 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Emission data from Swedish EPA: 155 kg CH4/cow (conventional), 12% higher emissions for organic cows
Impact per product unit conventional	0.01798 kg SO2-equ./kg ECM	**Productivity organic**	2887 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.01581 kg SO2-equ./kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-44%	**Calculation basis for N2O-emissions from soils and manure storag**	?
Impact per area and year conventional	93 kg SO2-equ./ ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	Heijungs et al. (1992)
Impact per area and year conventional	46 kg SO2-equ./ ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	-12%	**Delivered milk conventional**	7813 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	7127 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-51%	**Relative difference yield - delivered milk (basis = conv)**	-9%	**Uncertainty analysis on results**	yes
Significant difference (area and year)?	no testing	**Allocation rule for milk**	biological (according energy and protein requirements: 85% to milk / 15% to meat)		

Milk Sample 13 (Cederberg & Mattsson 2000) Remark: -

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	eutrophication	**Productivity conventional**	5195 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Emission data from Swedish EPA: 155 kg CH4/cow (conventional), 12% higher emissions for organic cows
Impact per product unit conventional	0.275 kg O2-equ./kg ECM	**Productivity organic**	2887 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.3 kg O2-equ./kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-44%	**Calculation basis for N2O-emissions from soils and manure storag**	?
Impact per area and year conventional	1429 kg O2-equ./ ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	Heijungs et al. (1992)
Impact per area and year conventional	866 kg O2-equ./ ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	9%	**Delivered milk conventional**	7813 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	7127 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-39%	**Relative difference yield - delivered milk (basis = conv)**	-9%	**Uncertainty analysis on results**	yes
Significant difference (area and year)?	no testing	**Allocation rule for milk**	biological (according energy and protein requirements: 85% to milk / 15% to meat)		

Flysjö et al. 2012 Sweden

Data source: primary data assessed on 6 organic and 9 conventional farm

Milk Sample 14 (Flysjö et al. 2012) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	GWP	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	1.07 kg CO2-equ. / kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	1.13 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (2006)
Impact per area and year conventional	6949 CO2-equ. / ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	3857 CO2-equ. / ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	6%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	see Cederberg and Flysjö (2004))	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per area and year (basis = conv)	-44%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	no allocation		

Milk Sample 15 (Flysjö et al. 2012) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	LUC included for soy meal (Gerber et al. 2010)
Impact category	GWP	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	1.42 kg CO2-equ. / kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	1.23 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (2006)
Impact per area and year conventional	9221 CO2-equ. / ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	4198 CO2-equ. / ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	-13%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	see Cederberg and Flysjö (2004))	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per area and year (basis = conv)	-54%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	no allocation		

Milk Sample 16 (Flysjö et al. 2012) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	LUC included for soy meal (Leip et al. 2010 --> medium case)
Impact category	GWP	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	1.21 kg CO2-equ. / kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	1.17 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (2006)
Impact per area and year conventional	7858 CO2-equ. / ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	3993 CO2-equ. / ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	-3%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	see Cederberg and Flysjö (2004))	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per area and year (basis = conv)	-49%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	no allocation		

Milk Sample 17 (Flysjö et al. 2012) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	LUC included for soy meal (Leip et al. 2010 --> worst case)
Impact category	GWP	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	1.52 kg CO2-equ. / kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	1.26 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (2006)
Impact per area and year conventional	9871 CO2-equ. / ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	4300 CO2-equ. / ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	-17%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	see Cederberg and Flysjö (2004))	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per area and year (basis = conv)	-56%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	no allocation		

Milk Sample 18 (Flysjö et al. 2012) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	LUC included for general land use (Audsley et al. 2009)
Impact category	GWP	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	1.32 kg CO2-equ. / kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	1.60 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (2006)
Impact per area and year conventional	8572 CO2-equ. / ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	5461 CO2-equ. / ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	21%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	see Cederberg and Flysjö (2004))	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per area and year (basis = conv)	-36%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	no allocation		

Milk Sample 19 (Flysjö et al. 2012) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	LUC included for general land use (Schmidt et al. 2011)
Impact category	GWP	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	2.07 kg CO2-equ. / kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	2.91 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (2006)
Impact per area and year conventional	13443 CO2-equ. / ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	9932 CO2-equ. / ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	41%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	see Cederberg and Flysjö (2004))	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per area and year (basis = conv)	-26%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	no allocation		

Milk Sample 20 (Flysjö et al. 2012) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	no LUC included
Impact category	GWP	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	0.52 kg CO2-equ. / kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.49 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (2006)
Impact per area and year conventional	3377 CO2-equ. / ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	1672 CO2-equ. / ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	-6%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	see Cederberg and Flysjö (2004))	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per area and year (basis = conv)	-50%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	system expansion EU beef		

Milk Sample 21 (Flysjö et al. 2012) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	LUC included for soy meal (Gerber et al. 2010)
Impact category	GWP	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	0.85 kg CO2-equ. / kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.56 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (2006)
Impact per area and year conventional	5520 CO2-equ. / ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	1911 CO2-equ. / ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	-34%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	see Cederberg and Flysjö (2004))	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per area and year (basis = conv)	-65%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	system expansion EU beef		

Milk Sample 22 (Flysjö et al. 2012) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	LUC included for soy meal (Leip et al. 2010 --> medium case)
Impact category	GWP	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	0.65 kg CO2-equ. / kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.52 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (2006)
Impact per area and year conventional	4221 CO2-equ. / ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	1775 CO2-equ. / ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	-20%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	see Cederberg and Flysjö (2004))	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per area and year (basis = conv)	-58%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	system expansion EU beef		

Milk Sample 23 (Flysjö et al. 2012) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	LUC included for soy meal (Leip et al. 2010 --> worst case)
Impact category	GWP	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	0.95 kg CO2-equ. / kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.59 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (2006)
Impact per area and year conventional	6169 CO2-equ. / ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	2014 CO2-equ. / ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	-38%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	see Cederberg and Flysjö (2004))	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per area and year (basis = conv)	-67%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	system expansion EU beef		

Milk Sample 24 (Flysjö et al. 2012) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	LUC included for general land use (Audsley et al. 2009)
Impact category	GWP	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	0.66 kg CO2-equ. / kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.83 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (2006)
Impact per area and year conventional	4286 CO2-equ. / ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	2833 CO2-equ. / ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	26%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	see Cederberg and Flysjö (2004))	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per area and year (basis = conv)	-34%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	system expansion EU beef		

Milk Sample 25 (Flysjö et al. 2012) Remark: organic compared with conventional high (> 7'500 kg ECM/ha)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	LUC included for general land use (Schmidt et al. 2011)
Impact category	GWP	**Productivity conventional**	6494 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	1.38 kg CO2-equ. / kg ECM	**Productivity organic**	3413 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	2.11 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (2006)
Impact per area and year conventional	8962 CO2-equ. / ha * y-1	**Total milk yield conventional**	10100 kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	7201 CO2-equ. / ha * y-1	**Total milk yield organic**	9400 kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	53%	**Delivered milk conventional**	9240 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	see Cederberg and Flysjö (2004))	**Delivered milk organic**	7690 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per area and year (basis = conv)	-20%	**Relative difference yield - delivered milk (basis = conv)**	-17%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	system expansion EU beef		

Grönroos et al. 2006 Finnland

Data source: primary data assessed on 1 organic and 1 conventional farm

Milk Sample 26 (Grönroos et al. 2006) Remark: allocated (according system expansion)milk fat content 1.5%

Landscape	?	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	energy demand	**Productivity conventional**	4032 kg milk / ha * year-1	**Calculation basis for enteric fermentation**	-
Impact per product unit conventional	4.14 MJ / l milk	**Productivity organic**	2770 kg milk / ha * year-1	**NH3-emissions dependend on ration considered?**	-
Impact per product unit organic	2.14 MJ / l milk	**Relative difference productivity - delivered milk (basis = conv)**	-31%	**Calculation basis for N2O-emissions from soils and manure storag**	-
Impact per area and year conventional	16692 MJ / ha * y-1	**Total milk yield conventional**	? kg milk/cow*y-1	**Impact assessment method**	Cumulative energy demand
Impact per area and year conventional	5928 MJ / ha * y-1	**Total milk yield organic**	? kg milk/cow*y-1	**Site specific emission- and characterization factors used**	-
Relative difference per product unit (basis = conv)	-48%	**Delivered milk conventional**	7700 kg milk/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	6800 kg milk/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-64%	**Relative difference yield - delivered milk (basis = conv)**	-12%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	according system expansion obtained in Cederberg & Mattson (2000): 87% to milk		

Milk Sample 27 (Grönroos et al. 2006) Remark: no allocationmilk fat content 1.5%

Landscape	?	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	energy demand	**Productivity conventional**	4032 kg milk / ha * year-1	**Calculation basis for enteric fermentation**	-
Impact per product unit conventional	4.77 MJ / l milk	**Productivity organic**	2770 kg milk / ha * year-1	**NH3-emissions dependend on ration considered?**	-
Impact per product unit organic	2.46 MJ / l milk	**Relative difference productivity - delivered milk (basis = conv)**	-31%	**Calculation basis for N2O-emissions from soils and manure storag**	-
Impact per area and year conventional	19233 MJ / ha * y-1	**Total milk yield conventional**	? kg milk/cow*y-1	**Impact assessment method**	Cumulative energy demand
Impact per area and year conventional	6814 MJ / ha * y-1	**Total milk yield organic**	? kg milk/cow*y-1	**Site specific emission- and characterization factors used**	-
Relative difference per product unit (basis = conv)	-48%	**Delivered milk conventional**	7700 kg milk/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	6800 kg milk/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-65%	**Relative difference yield - delivered milk (basis = conv)**	-12%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	none		

Milk Sample 28 (Grönroos et al. 2006) Remark: milk fat content 1.5%88% vom Landbedarf pro l Milch on fram

Landscape	?	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	land use	**Productivity conventional**	4032 kg milk / ha * year-1	**Calculation basis for enteric fermentation**	-
Impact per product unit conventional	2.48 m2 / l milk	**Productivity organic**	2770 kg milk / ha * year-1	**NH3-emissions dependend on ration considered?**	-
Impact per product unit organic	3.61 m2 / l milk	**Relative difference productivity - delivered milk (basis = conv)**	-31%	**Calculation basis for N2O-emissions from soils and manure storag**	-
Impact per area and year conventional	- m2 / ha * y-1	**Total milk yield conventional**	? kg milk/cow*y-1	**Impact assessment method**	-
Impact per area and year conventional	- m2 / ha * y-1	**Total milk yield organic**	? kg milk/cow*y-1	**Site specific emission- and characterization factors used**	-
Relative difference per product unit (basis = conv)	46%	**Delivered milk conventional**	7700 kg milk/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	6800 kg milk/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-	**Relative difference yield - delivered milk (basis = conv)**	-12%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	according system expansion obtained in Cederberg & Mattson (2000): 87% to milk		

Guerci et al. 2013 Denmark

Data source: data from 2 organic and 3 conventional dairy farms (values in the table here represent the average over the 2 organic and the 3 conventional farms respectively)

Milk Sample 29 (Guerci et al. 2013) Remark: Also dairy farming systems in Germany and Italy were assessed, but without a comparison of organic and conventional systems

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	GWP	**Productivity conventional**	9093 kg ECM / ha * y-1	**Calculation basis for enteric fermentation**	IPCC 2006
Impact per product unit conventional	1.5 kg CO2-equ. / kg ECM	**Productivity organic**	5092 kg ECM / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	1.3 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-44%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	13640 kg CO2-equ. / ha * y-1	**Total milk yield conventional**	? kg ECM / cow * y-1	**Impact assessment method**	EPD 1.03 (2008) [updated with IPCC 2006 GWP conversion factors (100 yr time horizon); value of CO2 emission from land transformation was set to 0]
Impact per area and year conventional	6441 kg CO2-equ. / ha * y-1	**Total milk yield organic**	? kg ECM / cow * y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	-16%	**Delivered milk conventional**	9215 kg ECM / cow * y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	6997 kg ECM / cow * y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-53%	**Relative difference yield - delivered milk (basis = conv)**	-24%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	biological allocation based on the feed energy required to produce the amount of milk and meat at farm level		

Milk Sample 30 (Guerci et al. 2014) Remark: Also dairy farming systems in Germany and Italy were assessed, but without a comparison of organic and conventional systems

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	acidification	**Productivity conventional**	9093 kg ECM / ha * y-1	**Calculation basis for enteric fermentation**	IPCC 2007
Impact per product unit conventional	0.018007 kg SO2-equ. / kg ECM	**Productivity organic**	5092 kg ECM / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.015700 kg SO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-44%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2007
Impact per area and year conventional	164 kg SO2-equ./ ha * y-1	**Total milk yield conventional**	? kg ECM / cow * y-1	**Impact assessment method**	EPD 1.03 (2008)
Impact per area and year conventional	80 kg SO2-equ./ ha * y-1	**Total milk yield organic**	? kg ECM / cow * y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	-13%	**Delivered milk conventional**	9215 kg ECM / cow * y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	6997 kg ECM / cow * y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-51%	**Relative difference yield - delivered milk (basis = conv)**	-24%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	biological allocation based on the feed energy required to produce the amount of milk and meat at farm level		

Milk Sample 31 (Guerci et al. 2015) Remark: Also dairy farming systems in Germany and Italy were assessed, but without a comparison of organic and conventional systems

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	eutrophication	**Productivity conventional**	9093 kg ECM / ha * y-1	**Calculation basis for enteric fermentation**	IPCC 2008
Impact per product unit conventional	0.008150 kg PO43--equ./ kg ECM	**Productivity organic**	5092 kg ECM / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.006965 kg PO43--equ./ kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-44%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2008
Impact per area and year conventional	74 kg PO43--equ./ ha * y-1	**Total milk yield conventional**	? kg ECM / cow * y-1	**Impact assessment method**	EPD 1.03 (2008)
Impact per area and year conventional	35 kg PO43--equ./ ha * y-1	**Total milk yield organic**	? kg ECM / cow * y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	-15%	**Delivered milk conventional**	9215 kg ECM / cow * y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	6997 kg ECM / cow * y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-52%	**Relative difference yield - delivered milk (basis = conv)**	-24%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	biological allocation based on the feed energy required to produce the amount of milk and meat at farm level		

Milk Sample 32 (Guerci et al. 2016) Remark: Also dairy farming systems in Germany and Italy were assessed, but without a comparison of organic and conventional systems

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	energy demand	**Productivity conventional**	9093 kg ECM / ha * y-1	**Calculation basis for enteric fermentation**	IPCC 2009
Impact per product unit conventional	3.8 MJ / kg ECM	**Productivity organic**	5092 kg ECM / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	2.7 MJ / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-44%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2009
Impact per area and year conventional	34342 MJ / ha * y-1	**Total milk yield conventional**	? kg ECM / cow * y-1	**Impact assessment method**	EPD 1.03 (2008)
Impact per area and year conventional	13799 MJ / ha * y-1	**Total milk yield organic**	? kg ECM / cow * y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	-28%	**Delivered milk conventional**	9215 kg ECM / cow * y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	6997 kg ECM / cow * y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-60%	**Relative difference yield - delivered milk (basis = conv)**	-24%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	biological allocation based on the feed energy required to produce the amount of milk and meat at farm level		

Milk Sample 33 (Guerci et al. 2017) Remark: Also dairy farming systems in Germany and Italy were assessed, but without a comparison of organic and conventional systems

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	land use	**Productivity conventional**	9093 kg ECM / ha * y-1	**Calculation basis for enteric fermentation**	IPCC 2010
Impact per product unit conventional	1.3 m2 / kg ECM	**Productivity organic**	5092 kg ECM / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	1.7 m2 / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-44%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2010
Impact per area and year conventional	- m2 / ha * y-1	**Total milk yield conventional**	? kg ECM / cow * y-1	**Impact assessment method**	EPD 1.03 (2008)
Impact per area and year conventional	- m2 / ha * y-1	**Total milk yield organic**	? kg ECM / cow * y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	38%	**Delivered milk conventional**	9215 kg ECM / cow * y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	6997 kg ECM / cow * y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-	**Relative difference yield - delivered milk (basis = conv)**	-24%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	biological allocation based on the feed energy required to produce the amount of milk and meat at farm level		

Haas et al. 2001 Germany

Data source: primary data assessed on 6 organic and 6 conventional farms

Milk Sample 34 (Haas et al. 2001) Remark: organic compared with conventional intensive

Landscape	up land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	energy demand	**Productivity conventional**	7153 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1991)
Impact per product unit conventional	2.7 MJ / kg milk	**Productivity organic**	4882 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	1.2 MJ / kg milk	**Relative difference productivity - delivered milk (basis = conv)**	-32%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (1996)
Impact per area and year conventional	19313 MJ / ha * y-1	**Total milk yield conventional**	? kg milk/cow*y-1	**Impact assessment method**	Cumulative energy demand
Impact per area and year conventional	5858 MJ / ha * y-1	**Total milk yield organic**	? kg milk/cow*y-1	**Site specific emission- and characterization factors used**	primary conumption factors of primary energy for Germany
Relative difference per product unit (basis = conv)	-56%	**Delivered milk conventional**	6758 kg milk/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	P < 0.05	**Delivered milk organic**	5275 kg milk/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-70%	**Relative difference yield - delivered milk (basis = conv)**	-22%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	none		

Milk Sample 35 (Haas et al. 2001) Remark: organic compared with conventional intensive

Landscape	up land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	GWP	**Productivity conventional**	7153 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1991)
Impact per product unit conventional	1.3 kg CO2-equ. /kg milk	**Productivity organic**	4882 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	1.3 kg CO2-equ. /kg milk	**Relative difference productivity - delivered milk (basis = conv)**	-32%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (1996)
Impact per area and year conventional	9299 kg CO2-equ. / ha * y-1	**Total milk yield conventional**	? kg milk/cow*y-1	**Impact assessment method**	IPCC (1996) GWP 100
Impact per area and year conventional	6347 kg CO2-equ. / ha * y-1	**Total milk yield organic**	? kg milk/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	0%	**Delivered milk conventional**	6758 kg milk/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	n.s.	**Delivered milk organic**	5275 kg milk/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-32%	**Relative difference yield - delivered milk (basis = conv)**	-22%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	none		

Milk Sample 36 (Haas et al. 2001) Remark: organic compared with conventional intensive

Landscape	up land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	acidification	**Productivity conventional**	7153 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1991)
Impact per product unit conventional	0.0201 kg SO2-equ./kg milk	**Productivity organic**	4882 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.0219 kg SO2-equ./kg milk	**Relative difference productivity - delivered milk (basis = conv)**	-32%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (1996)
Impact per area and year conventional	144 kg SO2-equ./ ha * y-1	**Total milk yield conventional**	? kg milk/cow*y-1	**Impact assessment method**	Reinhardt (1997)
Impact per area and year conventional	107 kg SO2-equ./ ha * y-1	**Total milk yield organic**	? kg milk/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	9%	**Delivered milk conventional**	6758 kg milk/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	P < 0.04	**Delivered milk organic**	5275 kg milk/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-26%	**Relative difference yield - delivered milk (basis = conv)**	-22%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	none		

Milk Sample 37 (Haas et al. 2001) Remark: organic compared with conventional intensive

Landscape	up land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	eutrophication	**Productivity conventional**	7153 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1991)
Impact per product unit conventional	0.0080 kg PO43--equ./kg milk	**Productivity organic**	4882 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.0028 kg PO43--equ./kg milk	**Relative difference productivity - delivered milk (basis = conv)**	-32%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (1996)
Impact per area and year conventional	57 kg PO43--equ./ ha * y-1	**Total milk yield conventional**	? kg milk/cow*y-1	**Impact assessment method**	Heijungs et al. (1992)
Impact per area and year conventional	13 kg PO43--equ./ ha * y-1	**Total milk yield organic**	? kg milk/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	-66%	**Delivered milk conventional**	6758 kg milk/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	P < 0.05	**Delivered milk organic**	5275 kg milk/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-76%	**Relative difference yield - delivered milk (basis = conv)**	-22%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	none		

Milk Sample 38 (Haas et al. 2001) Remark: organic compared with conventional intensive

Landscape	up land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	land use	**Productivity conventional**	7153 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1991)
Impact per product unit conventional	1.4 m2 / kg milk	**Productivity organic**	4882 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	2.0 m2 / kg milk	**Relative difference productivity - delivered milk (basis = conv)**	-32%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (1996)
Impact per area and year conventional	- m2 / ha * y-1	**Total milk yield conventional**	? kg milk/cow*y-1	**Impact assessment method**	-
Impact per area and year conventional	- m2 / ha * y-1	**Total milk yield organic**	? kg milk/cow*y-1	**Site specific emission- and characterization factors used**	-
Relative difference per product unit (basis = conv)	43%	**Delivered milk conventional**	6758 kg milk/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	5275 kg milk/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-	**Relative difference yield - delivered milk (basis = conv)**	-22%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	none		

Hörtenhuber et al. 2010 Austria

Data source: farm statistical data / database data / literature data

Milk Sample 39 (Hörtenhuber et al. 2010) Remark: standardized milk (4.1% fat / 3.5% protein)

Landscape	alpine	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	soya from South America (only for conventional): conversion of savannah-type vegetation to soybean fields
Impact category	GWP	**Productivity conventional**	4484 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	1.173 kg CO2-equ. / kg milk	**Productivity organic**	4098 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	1.017 kg CO2-equ. / kg milk	**Relative difference productivity - delivered milk (basis = conv)**	-9%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	5260 kg CO2-equ. / ha * y-1	**Total milk yield conventional**	? kg milk/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	4168 kg CO2-equ. / ha * y-1	**Total milk yield organic**	? kg milk/cow*y-1	**Site specific emission- and characterization factors used**	for fuel use
Relative difference per product unit (basis = conv)	-13%	**Delivered milk conventional**	5500 kg milk/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	5500 kg milk/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-21%	**Relative difference yield - delivered milk (basis = conv)**	0%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	own model calculating emissions of beef as by-product from cull cows and newborn calves and subtracting these emissions from total emissions of milk productioneach prodcution system		

Milk Sample 40 (Hörtenhuber et al. 2010) Remark: standardized milk (4.1% fat / 3.5% protein)

Landscape	alpine	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	soya from South America (only for conventional): conversion of savannah-type vegetation to soybean fields
Impact category	land use	**Productivity conventional**	4484 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	2.23 m2/kg milk	**Productivity organic**	4098 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	2.44 m2/kg milk	**Relative difference productivity - delivered milk (basis = conv)**	-9%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	- m2/ ha * y-1	**Total milk yield conventional**	? kg milk/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	- m2/ ha * y-1	**Total milk yield organic**	? kg milk/cow*y-1	**Site specific emission- and characterization factors used**	
Relative difference per product unit (basis = conv)	9%	**Delivered milk conventional**	5500 kg milk/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	5500 kg milk/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-	**Relative difference yield - delivered milk (basis = conv)**	0%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	own model calculating emissions of beef as by-product from cull cows and newborn calves and subtracting these emissions from total emissions of milk productioneach prodcution system		

Milk Sample 41 (Hörtenhuber et al. 2010) Remark: standardized milk (4.1% fat / 3.5% protein)

Landscape	up land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	soya from South America (only for conventional): conversion of savannah-type vegetation to soybean fields
Impact category	GWP	**Productivity conventional**	6579 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	1.032 kg CO2-equ. / kg milk	**Productivity organic**	6211 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.946 kg CO2-equ. / kg milk	**Relative difference productivity - delivered milk (basis = conv)**	-6%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	6790 kg CO2-equ. / ha * y-1	**Total milk yield conventional**	? kg milk/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	5876 kg CO2-equ. / ha * y-1	**Total milk yield organic**	? kg milk/cow*y-1	**Site specific emission- and characterization factors used**	for fuel use
Relative difference per product unit (basis = conv)	-8%	**Delivered milk conventional**	5500 kg milk/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	5500 kg milk/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-13%	**Relative difference yield - delivered milk (basis = conv)**	0%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	own model calculating emissions of beef as by-product from cull cows and newborn calves and subtracting these emissions from total emissions of milk productioneach prodcution system		

Milk Sample 42 (Hörtenhuber et al. 2010) Remark: standardized milk (4.1% fat / 3.5% protein)

Landscape	up land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	soya from South America (only for conventional): conversion of savannah-type vegetation to soybean fields
Impact category	land use	**Productivity conventional**	6579 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	1.52 m2/kg milk	**Productivity organic**	6211 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	1.61 m2/kg milk	**Relative difference productivity - delivered milk (basis = conv)**	-6%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	- m2/ ha * y-1	**Total milk yield conventional**	? kg milk/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	- m2/ ha * y-1	**Total milk yield organic**	? kg milk/cow*y-1	**Site specific emission- and characterization factors used**	
Relative difference per product unit (basis = conv)	6%	**Delivered milk conventional**	5500 kg milk/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	5500 kg milk/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-	**Relative difference yield - delivered milk (basis = conv)**	0%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	own model calculating emissions of beef as by-product from cull cows and newborn calves and subtracting these emissions from total emissions of milk productioneach prodcution system		

Milk Sample 43 (Hörtenhuber et al. 2010) Remark: standardized milk (4.1% fat / 3.5% protein)

Landscape	up land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	soya from South America (only for conventional): conversion of savannah-type vegetation to soybean fields
Impact category	GWP	**Productivity conventional**	6289 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	1.027 kg CO2-equ. / kg milk	**Productivity organic**	5917 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.908 kg CO2-equ. / kg milk	**Relative difference productivity - delivered milk (basis = conv)**	-6%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	6459 kg CO2-equ. / ha * y-1	**Total milk yield conventional**	? kg milk/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	5373 kg CO2-equ. / ha * y-1	**Total milk yield organic**	? kg milk/cow*y-1	**Site specific emission- and characterization factors used**	for fuel use
Relative difference per product unit (basis = conv)	-12%	**Delivered milk conventional**	7000 kg milk/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	6500 kg milk/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-17%	**Relative difference yield - delivered milk (basis = conv)**	-7%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	own model calculating emissions of beef as by-product from cull cows and newborn calves and subtracting these emissions from total emissions of milk productioneach prodcution system		

Milk Sample 44 (Hörtenhuber et al. 2010) Remark: standardized milk (4.1% fat / 3.5% protein)

Landscape	up land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	soya from South America (only for conventional): conversion of savannah-type vegetation to soybean fields
Impact category	land use	**Productivity conventional**	6289 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	1.59 m2/kg milk	**Productivity organic**	5917 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	1.69 m2/kg milk	**Relative difference productivity - delivered milk (basis = conv)**	-6%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	- m2/ ha * y-1	**Total milk yield conventional**	? kg milk/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	- m2/ ha * y-1	**Total milk yield organic**	? kg milk/cow*y-1	**Site specific emission- and characterization factors used**	
Relative difference per product unit (basis = conv)	6%	**Delivered milk conventional**	7000 kg milk/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	6500 kg milk/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-	**Relative difference yield - delivered milk (basis = conv)**	-7%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	own model calculating emissions of beef as by-product from cull cows and newborn calves and subtracting these emissions from total emissions of milk productioneach prodcution system		

Milk Sample 45 (Hörtenhuber et al. 2010) Remark: standardized milk (4.1% fat / 3.5% protein)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	soya from South America (only for conventional): conversion of savannah-type vegetation to soybean fields
Impact category	GWP	**Productivity conventional**	8547 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	0.898 kg CO2-equ. / kg milk	**Productivity organic**	7634 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.814 kg CO2-equ. / kg milk	**Relative difference productivity - delivered milk (basis = conv)**	-11%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	7675 kg CO2-equ. / ha * y-1	**Total milk yield conventional**	? kg milk/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	6214 kg CO2-equ. / ha * y-1	**Total milk yield organic**	? kg milk/cow*y-1	**Site specific emission- and characterization factors used**	for fuel use
Relative difference per product unit (basis = conv)	-9%	**Delivered milk conventional**	8000 kg milk/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	7000 kg milk/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-19%	**Relative difference yield - delivered milk (basis = conv)**	-13%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	own model calculating emissions of beef as by-product from cull cows and newborn calves and subtracting these emissions from total emissions of milk productioneach prodcution system		

Milk Sample 46 (Hörtenhuber et al. 2010) Remark: standardized milk (4.1% fat / 3.5% protein)

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	soya from South America (only for conventional): conversion of savannah-type vegetation to soybean fields
Impact category	land use	**Productivity conventional**	8547 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1995)
Impact per product unit conventional	1.17 m2/kg milk	**Productivity organic**	7634 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	1.31 m2/kg milk	**Relative difference productivity - delivered milk (basis = conv)**	-11%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	- m2/ ha * y-1	**Total milk yield conventional**	? kg milk/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	- m2/ ha * y-1	**Total milk yield organic**	? kg milk/cow*y-1	**Site specific emission- and characterization factors used**	
Relative difference per product unit (basis = conv)	12%	**Delivered milk conventional**	8000 kg milk/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	no testing	**Delivered milk organic**	7000 kg milk/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-	**Relative difference yield - delivered milk (basis = conv)**	-13%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	own model calculating emissions of beef as by-product from cull cows and newborn calves and subtracting these emissions from total emissions of milk productioneach prodcution system		

Kristensen et al. 2011 Denmark

Data source: primary data assessed on 32 organic and 35 conventional farm

Milk Sample 47 (Kristensen et al. 2011) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	land use	**Productivity conventional**	5618 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	EF 6% of herd DMI x 18.45 MJ brutto energy / 55.65
Impact per product unit conventional	1.78 m2/kg ECM	**Productivity organic**	4219 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	yes
Impact per product unit organic	2.37 m2/kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-25%	**Calculation basis for N2O-emissions from soils and manure storag**	calculated from N flow using IPCC-emission factors
Impact per area and year conventional	- m2/ ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	-
Impact per area and year conventional	- m2/ ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	
Relative difference per product unit (basis = conv)	33%	**Delivered milk conventional**	8201 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	n.s.	**Delivered milk organic**	7175 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-	**Relative difference yield - delivered milk (basis = conv)**	-13%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	none		

Milk Sample 48 (Kristensen et al. 2011) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	GWP	**Productivity conventional**	5618 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	IPCC (2006) / Tier 2
Impact per product unit conventional	1.20 kg CO2-equ. / kg ECM	**Productivity organic**	4219 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	yes
Impact per product unit organic	1.27 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-25%	**Calculation basis for N2O-emissions from soils and manure storag**	calculated from N flow using IPCC-emission factors
Impact per area and year conventional	6742 CO2-equ. / ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	5358 CO2-equ. / ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	
Relative difference per product unit (basis = conv)	6%	**Delivered milk conventional**	8201 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	$P < 0.05$	**Delivered milk organic**	7175 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-21%	**Relative difference yield - delivered milk (basis = conv)**	-13%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	none		

Milk Sample 49 (Kristensen et al. 2011) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	GWP	**Productivity conventional**	5618 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	IPCC (2006) / Tier 2
Impact per product unit conventional	1.03 kg CO2-equ. / kg ECM	**Productivity organic**	4219 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	yes
Impact per product unit organic	1.06 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-25%	**Calculation basis for N2O-emissions from soils and manure storag**	calculated from N flow using IPCC-emission factors
Impact per area and year conventional	5787 CO2-equ. / ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	4472 CO2-equ. / ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	
Relative difference per product unit (basis = conv)	3%	**Delivered milk conventional**	8201 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	n.s.	**Delivered milk organic**	7175 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-23%	**Relative difference yield - delivered milk (basis = conv)**	-13%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	own model: causal relationsship between total farm GHG emissions, total milk production and total meat production		

Milk Sample 50 (Kristensen et al. 2011) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	GWP	**Productivity conventional**	5618 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	IPCC (2006) / Tier 2
Impact per product unit conventional	0.99 kg CO2-equ. / kg ECM	**Productivity organic**	4219 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	yes
Impact per product unit organic	1.02 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-25%	**Calculation basis for N2O-emissions from soils and manure storag**	calculated from N flow using IPCC-emission factors
Impact per area and year conventional	5562 CO2-equ. / ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	4303 CO2-equ. / ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	
Relative difference per product unit (basis = conv)	3%	**Delivered milk conventional**	8201 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	n.s.	**Delivered milk organic**	7175 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-23%	**Relative difference yield - delivered milk (basis = conv)**	-13%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	protein mass		

Milk Sample 51 (Kristensen et al. 2011) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	GWP	**Productivity conventional**	5618 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	IPCC (2006) / Tier 2
Impact per product unit conventional	0.91 kg CO2-equ. / kg ECM	**Productivity organic**	4219 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	yes
Impact per product unit organic	0.90 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-25%	**Calculation basis for N2O-emissions from soils and manure storag**	calculated from N flow using IPCC-emission factors
Impact per area and year conventional	5112 CO2-equ. / ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	3797 CO2-equ. / ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	
Relative difference per product unit (basis = conv)	-1%	**Delivered milk conventional**	8201 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	n.s.	**Delivered milk organic**	7175 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-26%	**Relative difference yield - delivered milk (basis = conv)**	-13%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	biological		

Milk Sample 52 (Kristensen et al. 2011) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	GWP	**Productivity conventional**	5618 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	IPCC (2006) / Tier 2
Impact per product unit conventional	1.06 kg CO2-equ. / kg ECM	**Productivity organic**	4219 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	yes
Impact per product unit organic	1.10 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-25%	**Calculation basis for N2O-emissions from soils and manure storag**	calculated from N flow using IPCC-emission factors
Impact per area and year conventional	5955 CO2-equ. / ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	4641 CO2-equ. / ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	
Relative difference per product unit (basis = conv)	4%	**Delivered milk conventional**	8201 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	n.s.	**Delivered milk organic**	7175 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-22%	**Relative difference yield - delivered milk (basis = conv)**	-13%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic		

Milk Sample 53 (Kristensen et al. 2011) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	GWP	**Productivity conventional**	5618 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	IPCC (2006) / Tier 2
Impact per product unit conventional	0.94 kg CO2-equ. / kg ECM	**Productivity organic**	4219 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	yes
Impact per product unit organic	0.96 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-25%	**Calculation basis for N2O-emissions from soils and manure storag**	calculated from N flow using IPCC-emission factors
Impact per area and year conventional	5281 CO2-equ. / ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	4050 CO2-equ. / ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	
Relative difference per product unit (basis = conv)	2%	**Delivered milk conventional**	8201 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	n.s.	**Delivered milk organic**	7175 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-23%	**Relative difference yield - delivered milk (basis = conv)**	-13%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	system expansion: based on 50/50 on the emissions of pig meat and beef meat		

Thomassen et al. 2008 Holland

Data source: primary data assessed on 11 organic and 10 conventional farms

Milk Sample 54 (Thomassen et al. 2008) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	land use	**Productivity conventional**	7692 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Schils et al. (2006): differnt emission factors for organic and conventional
Impact per product unit conventional	1.3 m2 / kg ECM	**Productivity organic**	5556 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	1.8 m2 / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-28%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (2006)
Impact per area and year conventional	- m2 / ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	CML 2002
Impact per area and year conventional	- m2 / ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	-
Relative difference per product unit (basis = conv)	38%	**Delivered milk conventional**	8483 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	P < 0.001	**Delivered milk organic**	6571 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-	**Relative difference yield - delivered milk (basis = conv)**	-23%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic		

Milk Sample 55 (Thomassen et al. 2008) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	energy demand	**Productivity conventional**	7692 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Schils et al. (2006): differnt emission factors for organic and conventional
Impact per product unit conventional	5.0 MJ / kg ECM	**Productivity organic**	5556 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	3.1 MJ / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-28%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (2006)
Impact per area and year conventional	38460 MJ / ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	-
Impact per area and year conventional	17224 MJ / ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	-
Relative difference per product unit (basis = conv)	-38%	**Delivered milk conventional**	8483 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	P < 0.002	**Delivered milk organic**	6571 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-55%	**Relative difference yield - delivered milk (basis = conv)**	-23%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic		

Milk Sample 56 (Thomassen et al. 2008) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	eutrophication	**Productivity conventional**	7692 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Schils et al. (2006): differnt emission factors for organic and conventional
Impact per product unit conventional	0.11 kg NO3-equ./kg ECM	**Productivity organic**	5556 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.07 kg NO3-equ./kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-28%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (2006)
Impact per area and year conventional	846 kg NO3-equ./ ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	Heijungs et al. (1992)
Impact per area and year conventional	389 kg NO3-equ./ ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	-36%	**Delivered milk conventional**	8483 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	P < 0.003	**Delivered milk organic**	6571 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-54%	**Relative difference yield - delivered milk (basis = conv)**	-23%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic		

Milk Sample 57 (Thomassen et al. 2008) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	acidification	**Productivity conventional**	7692 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Schils et al. (2006): differnt emission factors for organic and conventional
Impact per product unit conventional	0.0095 kg SO2-equ./kg ECM	**Productivity organic**	5556 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	0.0108 kg SO2-equ./kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-28%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (2006)
Impact per area and year conventional	73 kg SO2-equ./ ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	Heijungs et al. (1992)
Impact per area and year conventional	60 kg SO2-equ./ ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	14%	**Delivered milk conventional**	8483 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	n.s.	**Delivered milk organic**	6571 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-18%	**Relative difference yield - delivered milk (basis = conv)**	-23%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic		

Milk Sample 58 (Thomassen et al. 2008) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	GWP	**Productivity conventional**	7692 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Schils et al. (2006): differnt emission factors for organic and conventional
Impact per product unit conventional	1.4 kg CO2-equ. /kg ECM	**Productivity organic**	5556 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	no
Impact per product unit organic	1.50 kg CO2-equ. /kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-28%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (2006)
Impact per area and year conventional	10769 kg CO2-equ. / ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	Houghton et al (1994)100 year time horizon
Impact per area and year conventional	8334 kg CO2-equ. / ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	no
Relative difference per product unit (basis = conv)	7%	**Delivered milk conventional**	8483 kg ECM/cow*y-1	**Capital goods**	not included
Significant difference (product unit)?	n.s.	**Delivered milk organic**	6571 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-23%	**Relative difference yield - delivered milk (basis = conv)**	-23%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic		

Van der Werf et al. 2009 France

Data source: primary data assessed on 6 organic and 41 conventional farms

Milk Sample 59 (Van der Werf et al. 2009) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	0
Impact category	eutrophication	**Productivity conventional**	7278 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	IPCC (2006) tier 2
Impact per product unit conventional	0.0071 kg PO43--equ / kg ECM	**Productivity organic**	4796 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	yes
Impact per product unit organic	0.005 kg PO43--equ / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-34%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	52 kg PO43--equ / ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	CML 2002
Impact per area and year conventional	24 kg PO43--equ / ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	average European
Relative difference per product unit (basis = conv)	-30%	**Delivered milk conventional**	7678 kg ECM/cow*y-1	**Capital goods**	included
Significant difference (product unit)?	n.s.	**Delivered milk organic**	5507 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-54%	**Relative difference yield - delivered milk (basis = conv)**	-28%	**Uncertainty analysis on results**	yes
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic		

Milk Sample 60 (Van der Werf et al. 2009) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	acidification	**Productivity conventional**	7278 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	IPCC (2006) tier 2
Impact per product unit conventional	0.0076 kg SO2-equ./kg ECM	**Productivity organic**	4796 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	yes
Impact per product unit organic	0.0068 kg SO2-equ./kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-34%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	55 kg SO2-equ./ ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	CML 2002
Impact per area and year conventional	33 kg SO2-equ./ ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	average European
Relative difference per product unit (basis = conv)	-11%	**Delivered milk conventional**	7678 kg ECM/cow*y-1	**Capital goods**	included
Significant difference (product unit)?	n.s.	**Delivered milk organic**	5507 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-41%	**Relative difference yield - delivered milk (basis = conv)**	-28%	**Uncertainty analysis on results**	yes
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic		

Milk Sample 61 (Van der Werf et al. 2009) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	GWP	**Productivity conventional**	7278 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	IPCC (2006) tier 2
Impact per product unit conventional	1.037 kg CO2-equ. / kg ECM	**Productivity organic**	4796 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	yes
Impact per product unit organic	1.082 kg CO2-equ. / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-34%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	7547 kg CO2-equ. / ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	IPCC (2007) GWP 100
Impact per area and year conventional	5189 kg CO2-equ. / ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	average European
Relative difference per product unit (basis = conv)	4%	**Delivered milk conventional**	7678 kg ECM/cow*y-1	**Capital goods**	included
Significant difference (product unit)?	n.s.	**Delivered milk organic**	5507 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-31%	**Relative difference yield - delivered milk (basis = conv)**	-28%	**Uncertainty analysis on results**	yes
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic		

Milk Sample 62 (Van der Werf et al. 2009) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	ecotox (terrestrial)	**Productivity conventional**	7278 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	IPCC (2006) tier 2
Impact per product unit conventional	0.00183 kg 1,4-DBC-eq./kg ECM	**Productivity organic**	4796 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	yes
Impact per product unit organic	0.00075 kg 1,4-DBC-eq./kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-34%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	13 kg 1,4-DBC-eq./ ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	CML 2002
Impact per area and year conventional	4 kg 1,4-DBC-eq./ ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	average European
Relative difference per product unit (basis = conv)	-59%	**Delivered milk conventional**	7678 kg ECM/cow*y-1	**Capital goods**	included
Significant difference (product unit)?	n.s.	**Delivered milk organic**	5507 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-73%	**Relative difference yield - delivered milk (basis = conv)**	-28%	**Uncertainty analysis on results**	yes
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic		

Milk Sample 63 (Van der Werf et al. 2009) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	energy demand	**Productivity conventional**	7278 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	IPCC (2006) tier 2
Impact per product unit conventional	0.0028 GJ/kg ECM	**Productivity organic**	4796 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	yes
Impact per product unit organic	0.0026 GJ/kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-34%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	20 GJ/ ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	Cumulative energy demand
Impact per area and year conventional	12 GJ/ ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	average European
Relative difference per product unit (basis = conv)	-7%	**Delivered milk conventional**	7678 kg ECM/cow*y-1	**Capital goods**	included
Significant difference (product unit)?	n.s.	**Delivered milk organic**	5507 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-39%	**Relative difference yield - delivered milk (basis = conv)**	-28%	**Uncertainty analysis on results**	yes
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic		

Milk Sample 64 (Van der Werf et al. 2009) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	land use	**Productivity conventional**	7278 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	IPCC (2006) tier 2
Impact per product unit conventional	1.374 m2 / kg ECM	**Productivity organic**	4796 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	yes
Impact per product unit organic	2.085 m2 / kg ECM	**Relative difference productivity - delivered milk (basis = conv)**	-34%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	- m2 / ha * y-1	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	-
Impact per area and year conventional	- m2 / ha * y-1	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	average European
Relative difference per product unit (basis = conv)	52%	**Delivered milk conventional**	7678 kg ECM/cow*y-1	**Capital goods**	included
Significant difference (product unit)?	P < 0.01	**Delivered milk organic**	5507 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-	**Relative difference yield - delivered milk (basis = conv)**	-28%	**Uncertainty analysis on results**	yes
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic		

Milk Sample 65 (Van der Werf et al. 2009) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	eutrophication	**Productivity conventional**	7278 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	IPCC (2006) tier 2
Impact per product unit conventional	39.8 kg PO43--equ./ha	**Productivity organic**	4796 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	yes
Impact per product unit organic	20.7 kg PO43--equ./ha	**Relative difference productivity - delivered milk (basis = conv)**	-34%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	289664 kg PO43--equ./ha	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	CML 2002
Impact per area and year conventional	99277 kg PO43--equ./ha	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	average European
Relative difference per product unit (basis = conv)	-48%	**Delivered milk conventional**	7678 kg ECM/cow*y-1	**Capital goods**	included
Significant difference (product unit)?	?	**Delivered milk organic**	5507 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-66%	**Relative difference yield - delivered milk (basis = conv)**	-28%	**Uncertainty analysis on results**	yes
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic		

Milk Sample 66 (Van der Werf et al. 2009) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	acidification	**Productivity conventional**	7278 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	IPCC (2006) tier 2
Impact per product unit conventional	48.1 kg SO2-equ./ha	**Productivity organic**	4796 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	yes
Impact per product unit organic	31.0 kg SO2-equ./ha	**Relative difference productivity - delivered milk (basis = conv)**	-34%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	350072 kg SO2-equ./ha	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	CML 2002
Impact per area and year conventional	148676 kg SO2-equ./ha	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	average European
Relative difference per product unit (basis = conv)	-36%	**Delivered milk conventional**	7678 kg ECM/cow*y-1	**Capital goods**	included
Significant difference (product unit)?	?	**Delivered milk organic**	5507 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-58%	**Relative difference yield - delivered milk (basis = conv)**	-28%	**Uncertainty analysis on results**	yes
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic		

Milk Sample 67 (Van der Werf et al. 2009) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	GWP	**Productivity conventional**	7278 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	IPCC (2006) tier 2
Impact per product unit conventional	6271 kg CO2-equ. /ha	**Productivity organic**	4796 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	yes
Impact per product unit organic	4887 kg CO2-equ. /ha	**Relative difference productivity - delivered milk (basis = conv)**	-34%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	45640338 kg CO2-equ. /ha	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	GWP 100
Impact per area and year conventional	23438052 kg CO2-equ. /ha	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	average European
Relative difference per product unit (basis = conv)	-22%	**Delivered milk conventional**	7678 kg ECM/cow*y-1	**Capital goods**	included
Significant difference (product unit)?	?	**Delivered milk organic**	5507 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-49%	**Relative difference yield - delivered milk (basis = conv)**	-28%	**Uncertainty analysis on results**	yes
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic		

Milk Sample 68 (Van der Werf et al. 2009) Remark:

Landscape	low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	ecotox (terrestrial)	**Productivity conventional**	7278 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	IPCC (2006) tier 2
Impact per product unit conventional	11.2 kg 1,4-DBC-eq./ha	**Productivity organic**	4796 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	yes
Impact per product unit organic	3.5 kg 1,4-DBC-eq./ha	**Relative difference productivity - delivered milk (basis = conv)**	-34%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per area and year conventional	81514 kg 1,4-DBC-eq./ha	**Total milk yield conventional**	? kg ECM/cow*y-1	**Impact assessment method**	CML 2002
Impact per area and year conventional	16786 kg 1,4-DBC-eq./ha	**Total milk yield organic**	? kg ECM/cow*y-1	**Site specific emission- and characterization factors used**	average European
Relative difference per product unit (basis = conv)	-69%	**Delivered milk conventional**	7678 kg ECM/cow*y-1	**Capital goods**	included
Significant difference (product unit)?	P < 0.05	**Delivered milk organic**	5507 kg ECM/cow*y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-79%	**Relative difference yield - delivered milk (basis = conv)**	-28%	**Uncertainty analysis on results**	yes
Significant difference (area and year)?	no testing	**Allocation rule for milk**	economic		

Williams et al. 2006 England & Wales

Data source: farm statistical data / database data / literature data / expert judgement

Milk Sample 69 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	energy demand	**Productivity conventional**	8403 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide. Influence of ration composition was considered.
Impact per product unit conventional	2.52 MJ / l milk	**Productivity organic**	5051 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	not clear, but NH3-emissions per cow are lower for organic
Impact per product unit organic	1.56 MJ / l milk	**Relative difference productivity - delivered milk (basis = conv)**	-40%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per area and year conventional	21176 MJ / ha * y-1	**Total milk yield conventional**	? l milk / cow * y-1	**Impact assessment method**	Cumulative energy demand
Impact per area and year conventional	7880 MJ / ha * y-1	**Total milk yield organic**	? l milk / cow * y-1	**Site specific emission- and characterization factors used**	
Relative difference per product unit (basis = conv)	-38%	**Delivered milk conventional**	6550 l milk / cow * y-1	**Capital goods**	included
Significant difference (product unit)?	no testing	**Delivered milk organic**	4950 l milk / cow * y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-63%	**Relative difference yield - delivered milk (basis = conv)**	-24%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	weight (mass) adjusted for lower economic value		

Milk Sample 70 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	GWP	**Productivity conventional**	8403 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide. Influence of ration composition was considered.
Impact per product unit conventional	1.06 kg CO2-equ. / l milk	**Productivity organic**	5051 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	not clear, but NH3-emissions per cow are lower for organic
Impact per product unit organic	1.23 kg CO2-equ. / l milk	**Relative difference productivity - delivered milk (basis = conv)**	-40%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per area and year conventional	8907 kg CO2-equ. / ha * y-1	**Total milk yield conventional**	? l milk / cow * y-1	**Impact assessment method**	GWP100 (emission factors: CO2 = 1, CH4 = 23, N2O = 296)
Impact per area and year conventional	6213 kg CO2-equ. / ha * y-1	**Total milk yield organic**	? l milk / cow * y-1	**Site specific emission- and characterization factors used**	yes
Relative difference per product unit (basis = conv)	16%	**Delivered milk conventional**	6550 l milk / cow * y-1	**Capital goods**	included
Significant difference (product unit)?	no testing	**Delivered milk organic**	4950 l milk / cow * y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-30%	**Relative difference yield - delivered milk (basis = conv)**	-24%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	weight (mass) adjusted for lower economic value		

Milk Sample 71 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	eutrophication	**Productivity conventional**	8403 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide. Influence of ration composition was considered.
Impact per product unit conventional	0.0063 kg PO43--equ. / l milk	**Productivity organic**	5051 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	not clear, but NH3-emissions per cow are lower for organic
Impact per product unit organic	0.0103 kg PO43--equ. / l milk	**Relative difference productivity - delivered milk (basis = conv)**	-40%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per area and year conventional	53 kg PO43--equ. / ha * y-1	**Total milk yield conventional**	? l milk / cow * y-1	**Impact assessment method**	based on NO3, PO4 and NH3 emissions quantified in terms of phosphate equivalents (1 kg NO3-N = 0.44 kg PO4, 1 kg NH3-N = 0.43 kg PO4)
Impact per area and year conventional	52 kg PO43--equ. / ha * y-1	**Total milk yield organic**	? l milk / cow * y-1	**Site specific emission- and characterization factors used**	
Relative difference per product unit (basis = conv)	63%	**Delivered milk conventional**	6550 l milk / cow * y-1	**Capital goods**	included
Significant difference (product unit)?	no testing	**Delivered milk organic**	4950 l milk / cow * y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-2%	**Relative difference yield - delivered milk (basis = conv)**	-24%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	weight (mass) adjusted for lower economic value		

Milk Sample 72 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	acidification	**Productivity conventional**	8403 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide. Influence of ration composition was considered.
Impact per product unit conventional	0.0162 kg SO2-equ. / l milk	**Productivity organic**	5051 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	not clear, but NH3-emissions per cow are lower for organic
Impact per product unit organic	0.0264 kg SO2-equ. / l milk	**Relative difference productivity - delivered milk (basis = conv)**	-40%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per area and year conventional	136 kg SO2-equ. / ha * y-1	**Total milk yield conventional**	? l milk / cow * y-1	**Impact assessment method**	based on SO2 and NH3 emissions quantified in terms of SO2 equivalents (1 kg NH3-N = 2.3 kg SO2)
Impact per area and year conventional	133 kg SO2-equ. / ha * y-1	**Total milk yield organic**	? l milk / cow * y-1	**Site specific emission- and characterization factors used**	
Relative difference per product unit (basis = conv)	63%	**Delivered milk conventional**	6550 l milk / cow * y-1	**Capital goods**	included
Significant difference (product unit)?	no testing	**Delivered milk organic**	4950 l milk / cow * y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-2%	**Relative difference yield - delivered milk (basis = conv)**	-24%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	weight (mass) adjusted for lower economic value		

Milk Sample 73 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	pesticide use	**Productivity conventional**	8403 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide. Influence of ration composition was considered.
Impact per product unit conventional	3.5 m2 / l milk	**Productivity organic**	5051 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	not clear, but NH3-emissions per cow are lower for organic
Impact per product unit organic	0 m2 / l milk	**Relative difference productivity - delivered milk (basis = conv)**	-40%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per area and year conventional	29411 m2 / ha * y-1	**Total milk yield conventional**	? l milk / cow * y-1	**Impact assessment method**	LCI
Impact per area and year conventional	0 m2 / ha * y-1	**Total milk yield organic**	? l milk / cow * y-1	**Site specific emission- and characterization factors used**	
Relative difference per product unit (basis = conv)	-100%	**Delivered milk conventional**	6550 l milk / cow * y-1	**Capital goods**	included
Significant difference (product unit)?	no testing	**Delivered milk organic**	4950 l milk / cow * y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-100%	**Relative difference yield - delivered milk (basis = conv)**	-24%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	weight (mass) adjusted for lower economic value		

Milk Sample 74 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	land use	**Productivity conventional**	8403 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide. Influence of ration composition was considered.
Impact per product unit conventional	1.19 m2 / l milk	**Productivity organic**	5051 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	not clear, but NH3-emissions per cow are lower for organic
Impact per product unit organic	1.98 m2 / l milk	**Relative difference productivity - delivered milk (basis = conv)**	-40%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per area and year conventional	- m2 / ha * y-1	**Total milk yield conventional**	? l milk / cow * y-1	**Impact assessment method**	LCI
Impact per area and year conventional	- m2 / ha * y-1	**Total milk yield organic**	? l milk / cow * y-1	**Site specific emission- and characterization factors used**	
Relative difference per product unit (basis = conv)	66%	**Delivered milk conventional**	6550 l milk / cow * y-1	**Capital goods**	included
Significant difference (product unit)?	no testing	**Delivered milk organic**	4950 l milk / cow * y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-	**Relative difference yield - delivered milk (basis = conv)**	-24%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	weight (mass) adjusted for lower economic value		

Milk Sample 75 (Williams et al. 2006) Remark: inludes most metals, minerals, fossil fuels and uranium for nuclear power

Landscape	mix of hill, up and low land	**Life cylce system boundary**	cradle to farm gate	**ILUC included**	not included
Impact category	abiotic resource use	**Productivity conventional**	8403 kg milk / ha * y-1	**Calculation basis for enteric fermentation**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide. Influence of ration composition was considered.
Impact per product unit conventional	0.0028 kg Sb equiv. / l milk	**Productivity organic**	5051 kg milk / ha * y-1	**NH3-emissions dependend on ration considered?**	not clear, but NH3-emissions per cow are lower for organic
Impact per product unit organic	0.0014 kg Sb equiv. / l milk	**Relative difference productivity - delivered milk (basis = conv)**	-40%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per area and year conventional	24 kg Sb equiv. / ha * y-1	**Total milk yield conventional**	? l milk / cow * y-1	**Impact assessment method**	CML (unclear which version)
Impact per area and year conventional	7 kg Sb equiv. / ha * y-1	**Total milk yield organic**	? l milk / cow * y-1	**Site specific emission- and characterization factors used**	
Relative difference per product unit (basis = conv)	-50%	**Delivered milk conventional**	6550 l milk / cow * y-1	**Capital goods**	included
Significant difference (product unit)?	no testing	**Delivered milk organic**	4950 l milk / cow * y-1	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per area and year (basis = conv)	-70%	**Relative difference yield - delivered milk (basis = conv)**	-24%	**Uncertainty analysis on results**	no
Significant difference (area and year)?	no testing	**Allocation rule for milk**	weight (mass) adjusted for lower economic value		

Alig et al. 2012 Switzerland

Data source: organic: 4 model farms based on data from a total of 1'216 organic farms;conventional: 5 model farms based on data from a total of 1'838 conventional farms

Beef Sample 1 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-26%	**NH3-emissions dependend on ration considered?**	no
Impact category	eutrophication potential aquatic P	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.0018 kg P / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	EDIP 2003
Impact per product unit organic	0.0017 kg P / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	no (global factors)
Impact per area and year conventional	1 kg P / ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	0 kg P / ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-6%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 2 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	10%	**NH3-emissions dependend on ration considered?**	no
Impact category	acidification	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	3 m2	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	EDIP 2003
Impact per product unit organic	4.2 m2	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	no (global factors)
Impact per area and year conventional	1116 m2	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	1231 m2	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	40%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 3 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-39%	**NH3-emissions dependend on ration considered?**	no
Impact category	ecotox terrestrial without pesticides	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.0039 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CML01
Impact per product unit organic	0.003 kg 1,4-DB eq. / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	1 kg 1,4-DB eq. / ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	1 kg 1,4-DB eq. / ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-23%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 4 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-97%	**NH3-emissions dependend on ration considered?**	no
Impact category	ecotox terrestrial incl. pesticides	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.0027 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CML01
Impact per product unit organic	<0.0001 kg 1,4-DB eq. / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	1 kg 1,4-DB eq. / ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	0 kg 1,4-DB eq. / ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-96%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 5 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-23%	**NH3-emissions dependend on ration considered?**	no
Impact category	ecotox aquatic without pesticides	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.046 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CML01
Impact per product unit organic	0.045 kg 1,4-DB eq. / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	17 kg 1,4-DB eq. / ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	13 kg 1,4-DB eq. / ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-2%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 6 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-99%	**NH3-emissions dependend on ration considered?**	no
Impact category	ecotox aquatic incl. pesticides	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.095 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CML01
Impact per product unit organic	<0.001 kg 1,4-DB eq. / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	35 kg 1,4-DB eq. / ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	0 kg 1,4-DB eq. / ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-99%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 7 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-21%	**NH3-emissions dependend on ration considered?**	no
Impact category	human tox without pesticides	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	2.45 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CML01
Impact per product unit organic	2.46 kg 1,4-DB eq. / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	911 kg 1,4-DB eq. /ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	721 kg 1,4-DB eq. /ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	0%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 8 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-74%	**NH3-emissions dependend on ration considered?**	no
Impact category	human tox incl. pesticides	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.03 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CML01
Impact per product unit organic	<0.01 kg 1,4-DB eq. / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	11 kg 1,4-DB eq. / ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	3 kg 1,4-DB eq. / ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-67%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 9 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-44%	**NH3-emissions dependend on ration considered?**	no
Impact category	energy demand	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	36.1 MJ / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CED (ecoinvent)
Impact per product unit organic	55.2 MJ / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	29819 MJ / ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	16560 MJ / ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	53%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 10 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-60%	**NH3-emissions dependend on ration considered?**	no
Impact category	GWP	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	8.8 kg CO2 equ. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	IPCC 2006
Impact per product unit organic	9.8 kg CO2 equ. / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	7269 kg CO2 equ. /ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	2940 kg CO2 equ. /ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	11%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 11 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-61%	**NH3-emissions dependend on ration considered?**	no
Impact category	Ozon vegetation	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	93.1 m2.ppm.h / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	EDIP03
Impact per product unit organic	100.3 m2.ppm.h / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	no (global factors)
Impact per area and year conventional	76901 m2.ppm.h /ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	30090 m2.ppm.h /ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	8%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 12 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-58%	**NH3-emissions dependend on ration considered?**	no
Impact category	ozon human	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.007 person.ppm.h / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	EDIP03
Impact per product unit organic	0.008 person.ppm.h / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	no (global factors)
Impact per area and year conventional	6 person.ppm.h /ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	2 person.ppm.h /ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	14%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 13 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-99%	**NH3-emissions dependend on ration considered?**	no
Impact category	resource use P	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.0119 kg / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	LCI
Impact per product unit organic	0.0004 kg / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	10 kg /ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	0 kg /ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-97%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 14 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-98%	**NH3-emissions dependend on ration considered?**	no
Impact category	resource use K	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.031 kg / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	LCI
Impact per product unit organic	0.0015 kg / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	26 kg /ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	0 kg /ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-95%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 15 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-0%	**NH3-emissions dependend on ration considered?**	no
Impact category	land use	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	12.1 m2*a / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CLM01
Impact per product unit organic	33.3 m2*a / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	9995 m2*a /ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	9990 m2*a /ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	175%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 16 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-89%	**NH3-emissions dependend on ration considered?**	no
Impact category	arable land use	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	4.3 m2*a / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CLM01
Impact per product unit organic	1.3 m2*a / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	3552 m2*a / ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	390 m2*a / ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-70%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 17 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-99%	**NH3-emissions dependend on ration considered?**	no
Impact category	deforested land use	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.0217 m2 / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	LCI
Impact per product unit organic	0.0005 m2 / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	18 m2 / ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	0 m2 / ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-98%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 18 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-59%	**NH3-emissions dependend on ration considered?**	no
Impact category	water use	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.058 m3 / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	LCI
Impact per product unit organic	0.066 m3 / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	48 m3 / ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	20 m3 / ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	14%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 19 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-31%	**NH3-emissions dependend on ration considered?**	no
Impact category	eutrophication potential terrestric	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	6.7 m2 / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	EDIP 2003
Impact per product unit organic	12.8 m2 / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	no (global factors)
Impact per area and year conventional	5534 m2 / ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	3840 m2 / ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	91%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 20 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-39%	**NH3-emissions dependend on ration considered?**	no
Impact category	eutrophication potential aquatic N	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.03 kg N / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	EDIP 2003
Impact per product unit organic	0.05 kg N / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	no (global factors)
Impact per area and year conventional	25 kg N / ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	15 kg N / ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	67%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 21 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-44%	**NH3-emissions dependend on ration considered?**	no
Impact category	eutrophication potential aquatic P	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.0011 kg P / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	EDIP 2003
Impact per product unit organic	0.0017 kg P / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	no (global factors)
Impact per area and year conventional	1 kg P / ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	1 kg P / ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	55%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 22 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-34%	**NH3-emissions dependend on ration considered?**	no
Impact category	acidification	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	1.7 m2	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	EDIP03
Impact per product unit organic	3.1 m2	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	no (global factors)
Impact per area and year conventional	1404 m2	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	930 m2	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	82%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 23 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-98%	**NH3-emissions dependend on ration considered?**	no
Impact category	ecotox terrestrial without pesticides	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.034 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CML01
Impact per product unit organic	0.0021 kg 1,4-DB eq. / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	28 kg 1,4-DB eq. / ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	1 kg 1,4-DB eq. / ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-94%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 24 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-99%	**NH3-emissions dependend on ration considered?**	no
Impact category	ecotox terrestrial incl. pesticides	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.0046 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CML01
Impact per product unit organic	<0.0001 kg 1,4-DB eq. / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	4 kg 1,4-DB eq. / ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	0 kg 1,4-DB eq. / ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-98%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 25 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-53%	**NH3-emissions dependend on ration considered?**	no
Impact category	ecotox aquatic without pesticides	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.033 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CML01
Impact per product unit organic	0.043 kg 1,4-DB eq. / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	27 kg 1,4-DB eq. / ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	13 kg 1,4-DB eq. / ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	30%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 26 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-100%	**NH3-emissions dependend on ration considered?**	no
Impact category	ecotox aquatic incl. pesticides	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.151 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CML01
Impact per product unit organic	<0.001 kg 1,4-DB eq. / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	125 kg 1,4-DB eq. / ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	0 kg 1,4-DB eq. / ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-99%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 27 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-45%	**NH3-emissions dependend on ration considered?**	no
Impact category	human tox without pesticides	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	1.7 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CML01
Impact per product unit organic	2.57 kg 1,4-DB eq. / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	1404 kg 1,4-DB eq. /ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	771 kg 1,4-DB eq. /ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	51%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 28 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	steer production	**Relative difference per area and year (basis = conv)**	-95%	**NH3-emissions dependend on ration considered?**	no
Impact category	human tox incl. pesticides	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.07 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CML01
Impact per product unit organic	<0.01 kg 1,4-DB eq. / kg LW	**Productivity conventional**	826 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	58 kg 1,4-DB eq. / ha * y-1	**Productivity organic**	300 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	3 kg 1,4-DB eq. / ha * y-1	**Relative difference productivity (basis = conv)**	-64	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-86%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 38 (Alig et al. 2012) Remark: inludes most metals, minerals, fossil fuels and uranium for nuclear powe

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-22%	**NH3-emissions dependend on ration considered?**	no
Impact category	energy demand	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	46.3 MJ / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CED (ecoinvent)
Impact per product unit organic	45.6 MJ / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	17224 MJ / ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	13361 MJ / ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-2%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 39 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-24%	**NH3-emissions dependend on ration considered?**	no
Impact category	GWP	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	15.3 kg CO2 equ. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	IPCC 2006
Impact per product unit organic	14.8 kg CO2 equ. / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	5692 kg CO2 equ. /ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	4336 kg CO2 equ. /ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-3%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 40 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-22%	**NH3-emissions dependend on ration considered?**	no
Impact category	Ozon vegetation	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	164.1 m2.ppm.h / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	EDIP03
Impact per product unit organic	162.5 m2.ppm.h / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	no (global factors)
Impact per area and year conventional	61045 m2.ppm.h /ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	47613 m2.ppm.h /ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-1%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 41 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-21%	**NH3-emissions dependend on ration considered?**	no
Impact category	ozon human	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.013 person.ppm.h / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	EDIP03
Impact per product unit organic	0.013 person.ppm.h / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	no (global factors)
Impact per area and year conventional	5 person.ppm.h /ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	4 person.ppm.h /ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	0%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 42 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-97%	**NH3-emissions dependend on ration considered?**	no
Impact category	resource use P	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.0164 kg / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	LCI
Impact per product unit organic	0.0006 kg / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	6 kg /ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	0 kg /ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-96%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 43 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-90%	**NH3-emissions dependend on ration considered?**	no
Impact category	resource use K	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.0078 kg / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	LCI
Impact per product unit organic	0.001 kg / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	3 kg /ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	0 kg /ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-87%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 44 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-0%	**NH3-emissions dependend on ration considered?**	no
Impact category	land use	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	26.9 m2*a / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CLM01
Impact per product unit organic	34.1 m2*a / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	10007 m2*a /ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	9991 m2*a /ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	27%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 45 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-32%	**NH3-emissions dependend on ration considered?**	no
Impact category	arable land use	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	2.2 m2*a / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CLM01
Impact per product unit organic	1.9 m2*a / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	818 m2*a / ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	557 m2*a / ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-14%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 46 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-21%	**NH3-emissions dependend on ration considered?**	no
Impact category	deforested land use	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.0005 m2 / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	LCI
Impact per product unit organic	0.0005 m2 / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	0 m2 / ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	0 m2 / ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	0%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 47 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-33%	**NH3-emissions dependend on ration considered?**	no
Impact category	water use	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.122 m3 / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	LCI
Impact per product unit organic	0.104 m3 / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	45 m3 / ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	30 m3 / ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-15%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 48 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	12%	**NH3-emissions dependend on ration considered?**	no
Impact category	eutrophication potential terrestric	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	12.6 m2 / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	EDIP 2003
Impact per product unit organic	17.9 m2 / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	no (global factors)
Impact per area and year conventional	4687 m2 / ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	5245 m2 / ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	42%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Beef Sample 49 (Alig et al. 2012) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Kirchgessner et al. (1993)
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-8%	**NH3-emissions dependend on ration considered?**	no
Impact category	eutrophication potential aquatic N	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.06 kg N / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	EDIP 2003
Impact per product unit organic	0.07 kg N / kg LW	**Productivity conventional**	372 kg LW / ha * y-1	**Site specific emission- and characterization factors used**	no (global factors)
Impact per area and year conventional	22 kg N / ha * y-1	**Productivity organic**	293 kg LW / ha * y-1	**Capital goods**	included
Impact per area and year conventional	21 kg N / ha * y-1	**Relative difference productivity (basis = conv)**	-21%	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	17%	**ILUC included**	included	**Uncertainty analysis on results**	yes

Casey & Holden 2006 Irland

Data source: primary data assessed on 5 organic and 5 conventional farms

Beef Sample 29 (Casey & Holden 2006) Remark:

Landscape	lowland	**Significant difference (product unit)?**	P < 0.01	**Calculation basis for enteric fermentation**	IPCC (1996) tier 2
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-57%	**NH3-emissions dependend on ration considered?**	no
Impact category	GWP	**Significant difference (area and year)?**	P < 0.01	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (1996) and local emission data
Impact per product unit conventional	13.0 kg CO2-equ./kg LW * y-1	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	IPCC (1996) GWP 100
Impact per product unit organic	11.1 kg CO2-equ./kg LW * y-1	**Productivity conventional**	412 kg LW / ha	**Site specific emission- and characterization factors used**	yes, for CH4 from dung and pasture and for N2O and CH4 from slurry application
Impact per area and year conventional	5356 kg CO2-equ./ ha * y-1	**Productivity organic**	206 kg LW / ha	**Capital goods**	not included
Impact per area and year conventional	2287 kg CO2-equ./ ha * y-1	**Relative difference productivity (basis = conv)**	-50%	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	-15%	**ILUC included**	not included	**Uncertainty analysis on results**	yes

Beef Sample 30 (Casey & Holden 2006) Remark:

Landscape	lowland	**Significant difference (product unit)?**	P < 0.01	**Calculation basis for enteric fermentation**	IPCC (1996) tier 2
Beef production system	suckler cow	**Relative difference per area and year (basis = conv)**	-	**NH3-emissions dependend on ration considered?**	no
Impact category	land use	**Significant difference (area and year)?**	P < 0.01	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC (1996) and local emission data
Impact per product unit conventional	24 m2 / kg LW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	IPCC (1996) GWP 102
Impact per product unit organic	49 m2 / kg LW	**Productivity conventional**	412 kg LW / ha	**Site specific emission- and characterization factors used**	yes, for CH4 from dung and pasture and for N2O and CH4 from slurry application
Impact per area and year conventional	- m2 / ha * y-1	**Productivity organic**	206 kg LW / ha	**Capital goods**	not included
Impact per area and year conventional	- m2 / ha * y-1	**Relative difference productivity (basis = conv)**	-50%	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	104%	**ILUC included**	not included	**Uncertainty analysis on results**	yes

Williams et al. 2006 England & Wales

Data source: farm statistical data / database data / literature data / expert judgement

Beef Sample 31 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide. Influence of ration composition was considered.
Beef production system	mix of suckler cow and beef as by-product from milk production	**Relative difference per area and year (basis = conv)**	-64%	**NH3-emissions dependend on ration considered?**	not clear, but NH3-emissions per cow are lower for organic
Impact category	energy demand	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit conventional	27.8 MJ/kg DW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	Cumulative energy demand
Impact per product unit organic	18.1 MJ/kg DW	**Productivity conventional**	435 kg DW / ha	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	12087 MJ/ha * y-1	**Productivity organic**	238 kg DW / ha	**Capital goods**	included
Impact per area and year conventional	4299 MJ/ha * y-1	**Relative difference productivity (basis = conv)**	-45%	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	-35%	**ILUC included**	not included	**Uncertainty analysis on results**	no

Beef Sample 32 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide. Influence of ration composition was considered.
Beef production system	mix of suckler cow and beef as by-product from milk production	**Relative difference per area and year (basis = conv)**	-37%	**NH3-emissions dependend on ration considered?**	not clear, but NH3-emissions per cow are lower for organic
Impact category	GWP	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit conventional	15.8 kg CO2-equ./kg DW * y-1	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	GWP100 (emission factors: CO2 = 1, CH4 = 23, N2O = 296)
Impact per product unit organic	18.2 kg CO2-equ./kg DW * y-1	**Productivity conventional**	435 kg DW / ha	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	6870 kg CO2-equ./ha * y-1	**Productivity organic**	238 kg DW / ha	**Capital goods**	included
Impact per area and year conventional	4323 kg CO2-equ./ha * y-1	**Relative difference productivity (basis = conv)**	-45%	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	15%	**ILUC included**	not included	**Uncertainty analysis on results**	no

Beef Sample 33 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide. Influence of ration composition was considered.
Beef production system	mix of suckler cow and beef as by-product from milk production	**Relative difference per area and year (basis = conv)**	13%	**NH3-emissions dependend on ration considered?**	not clear, but NH3-emissions per cow are lower for organic
Impact category	eutrophication	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit conventional	0.157 kg PO43--equ / kg DW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	based on NO3, PO4 and NH3 emissions quantified in terms of phosphate equivalents (1 kg NO3-N = 0.44 kg PO4, 1 kg NH3-N = 0.43 kg PO4)
Impact per product unit organic	0.326 kg PO43--equ / kg DW	**Productivity conventional**	435 kg DW / ha	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	68 kg PO43--equ / ha * y-1	**Productivity organic**	238 kg DW / ha	**Capital goods**	included
Impact per area and year conventional	77 kg PO43--equ / ha * y-1	**Relative difference productivity (basis = conv)**	-45%	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	108%	**ILUC included**	not included	**Uncertainty analysis on results**	no

Beef Sample 34 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide. Influence of ration composition was considered.
Beef production system	mix of suckler cow and beef as by-product from milk production	**Relative difference per area and year (basis = conv)**	-17%	**NH3-emissions dependend on ration considered?**	not clear, but NH3-emissions per cow are lower for organic
Impact category	acidification	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit conventional	0.469 kg SO2-equ./kg DW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	based on SO2 and NH3 emissions quantified in terms of SO2 equivalents (1 kg NH3-N = 2.3 kg SO2)
Impact per product unit organic	0.711 kg SO2-equ./kg DW	**Productivity conventional**	435 kg DW / ha	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	204 kg SO2-equ./ha * y-1	**Productivity organic**	238 kg DW / ha	**Capital goods**	included
Impact per area and year conventional	169 kg SO2-equ./ha * y-1	**Relative difference productivity (basis = conv)**	-45%	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	52%	**ILUC included**	not included	**Uncertainty analysis on results**	no

Beef Sample 35 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide. Influence of ration composition was considered.
Beef production system	mix of suckler cow and beef as by-product from milk production	**Relative difference per area and year (basis = conv)**	-100%	**NH3-emissions dependend on ration considered?**	not clear, but NH3-emissions per cow are lower for organic
Impact category	pesticide use	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit conventional	72 m2 / kg DW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	Based on annual pesticide survey
Impact per product unit organic	0 m2 / kg DW	**Productivity conventional**	435 kg DW / ha	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	31304 m2 / ha * y-1	**Productivity organic**	238 kg DW / ha	**Capital goods**	included
Impact per area and year conventional	0 m2 / ha * y-1	**Relative difference productivity (basis = conv)**	-45%	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	-100%	**ILUC included**	not included	**Uncertainty analysis on results**	no

Beef Sample 36 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide. Influence of ration composition was considered.
Beef production system	mix of suckler cow and beef as by-product from milk production	**Relative difference per area and year (basis = conv)**	-	**NH3-emissions dependend on ration considered?**	not clear, but NH3-emissions per cow are lower for organic
Impact category	land use	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit conventional	23 m2 / kg DW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	yields were scaled on different grades of agricultural land
Impact per product unit organic	42.1 m2 / kg DW	**Productivity conventional**	435 kg DW / ha	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	- m2 / ha * y-1	**Productivity organic**	238 kg DW / ha	**Capital goods**	included
Impact per area and year conventional	- m2 / ha * y-1	**Relative difference productivity (basis = conv)**	-45%	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	83%	**ILUC included**	not included	**Uncertainty analysis on results**	no

Beef Sample 37 (Williams et al. 2006) Remark: inludes most metals, minerals, fossil fuels and uranium for nuclear powe

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**Calculation basis for enteric fermentation**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide. Influence of ration composition was considered.
Beef production system	mix of suckler cow and beef as by-product from milk production	**Relative difference per area and year (basis = conv)**	-53%	**NH3-emissions dependend on ration considered?**	not clear, but NH3-emissions per cow are lower for organic
Impact category	abiotic resource use	**Significant difference (area and year)?**	no testing	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit conventional	0.036 kg Sb equiv. / kg DW	**Life cylce system boundary**	cradle to farm gate	**Impact assessment method**	CML (unclear which version)
Impact per product unit organic	0.031 kg Sb equiv. / kg DW	**Productivity conventional**	435 kg DW / ha	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	16 kg Sb equiv. / ha * y-1	**Productivity organic**	238 kg DW / ha	**Capital goods**	included
Impact per area and year conventional	7 kg Sb equiv. / ha * y-1	**Relative difference productivity (basis = conv)**	-45%	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	-14%	**ILUC included**	not included	**Uncertainty analysis on results**	no

Alig et al. 2012 Switzerland

Data source: organic: 2 model farms based on data from a total of 258 organic farms;conventional: 4 model farms based on data from a total of 5397 conventional farms

Pork Sample 1 (Alig et al. 2012) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	energy demand	**Relative difference per area and year (basis = conv)**	-39%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	30.1 MJ / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CED (ecoinvent)
Impact per product unit organic	31.8 MJ / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	70'013 MJ / ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	42'389 MJ / ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	6%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 2 (Alig et al. 2012) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-41%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	3.3 kg CO2 equ. / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	IPCC 2006
Impact per product unit organic	3.4 kg CO2 equ. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	7'676 kg CO2 equ. /ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	4'532 kg CO2 equ. /ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	3%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 3 (Alig et al. 2012) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	Ozon vegetation	**Relative difference per area and year (basis = conv)**	-36%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	28.1 m2.ppm.h / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	EDIP03
Impact per product unit organic	31.6 m2.ppm.h / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no (global)
Impact per area and year conventional	65'361 m2.ppm.h /ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	42'123 m2.ppm.h /ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	12%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 4 (Alig et al. 2012) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	ozon human	**Relative difference per area and year (basis = conv)**	-34%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.002 person.ppm.h / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	EDIP03
Impact per product unit organic	0.0023 person.ppm.h / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no (global)
Impact per area and year conventional	5 person.ppm.h /ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	3 person.ppm.h /ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	15%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 5 (Alig et al. 2012) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	resource use P	**Relative difference per area and year (basis = conv)**	-94%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.009 kg / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	LCI
Impact per product unit organic	0.001 kg / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	21 kg /ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	1 kg /ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-89%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 6 (Alig et al. 2012) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	resource use K	**Relative difference per area and year (basis = conv)**	-96%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.015 kg / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	LCI
Impact per product unit organic	0.001 kg / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	35 kg /ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	1 kg /ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-93%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 7 (Alig et al. 2012) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	land use	**Relative difference per area and year (basis = conv)**	-	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	4.3 m2*a / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CLM01
Impact per product unit organic	7.5 m2*a / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	- m2*a /ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	- m2*a /ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	74%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 8 (Alig et al. 2012) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	arable land use	**Relative difference per area and year (basis = conv)**	4%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	3.8 m2*a / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CLM01
Impact per product unit organic	6.9 m2*a / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	8'839 m2*a / ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	9'198 m2*a / ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	82%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 9 (Alig et al. 2012) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	deforested land use	**Relative difference per area and year (basis = conv)**	-98%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.03 m2 / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	LCI
Impact per product unit organic	0.001 m2 / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	70 m2 / ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	1 m2 / ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-97%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 10 (Alig et al. 2012) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	water use	**Relative difference per area and year (basis = conv)**	-45%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.028 m3 / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	LCI
Impact per product unit organic	0.027 m3 / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	65 m3 / ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	36 m3 / ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-4%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 11 (Alig et al. 2012) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	eutrophication potential terrestric	**Relative difference per area and year (basis = conv)**	24%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	1.9 m2 / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	EDIP 2003
Impact per product unit organic	4.1 m2 / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no (global)
Impact per area and year conventional	4'419 m2 / ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	5'465 m2 / ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	116%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 12 (Alig et al. 2012) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	eutrophication potential aquatic N	**Relative difference per area and year (basis = conv)**	-0%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.019 kg N / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	EDIP 2003
Impact per product unit organic	0.033 kg N / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no (global)
Impact per area and year conventional	44 kg N / ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	44 kg N / ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	74%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 13 (Alig et al. 2012) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	eutrophication potential aquatic P	**Relative difference per area and year (basis = conv)**	-54%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.0005 kg P / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	EDIP 2003
Impact per product unit organic	0.0004 kg P / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no (global)
Impact per area and year conventional	1 kg P / ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	1 kg P / ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-20%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 14 (Alig et al. 2012) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	acidification	**Relative difference per area and year (basis = conv)**	12%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.52 m2	**Significant difference (area and year)?**	no testing	**Impact assessment method**	EDIP03
Impact per product unit organic	1.02 m2	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no (global)
Impact per area and year conventional	1'210 m2	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	1'360 m2	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	96%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 15 (Alig et al. 2012) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	ecotox terrestrial without pesticides	**Relative difference per area and year (basis = conv)**	54%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.0026 kg 1,4-DB eq. / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CML01
Impact per product unit organic	0.007 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	6 kg 1,4-DB eq. / ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	9 kg 1,4-DB eq. / ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	169%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 16 (Alig et al. 2013) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	ecotox terrestrial incl. pesticides	**Relative difference per area and year (basis = conv)**	-98%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.0056 kg 1,4-DB eq. / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CML01
Impact per product unit organic	0.0002 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	13 kg 1,4-DB eq. / ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	0 kg 1,4-DB eq. / ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-96%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 17 (Alig et al. 2014) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	ecotox aquatic without pesticides	**Relative difference per area and year (basis = conv)**	4%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.0348 kg 1,4-DB eq. / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CML01
Impact per product unit organic	0.0634 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	81 kg 1,4-DB eq. / ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	85 kg 1,4-DB eq. / ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	82%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 18 (Alig et al. 2015) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	ecotox aquatic incl. pesticides	**Relative difference per area and year (basis = conv)**	-99%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.1856 kg 1,4-DB eq. / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CML01
Impact per product unit organic	0.0046 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	432 kg 1,4-DB eq. / ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	6 kg 1,4-DB eq. / ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-98%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 19 (Alig et al. 2016) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	human tox without pesticides	**Relative difference per area and year (basis = conv)**	-44%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	1.13 kg 1,4-DB eq. / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CML01
Impact per product unit organic	1.1 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	2'628 kg 1,4-DB eq. /ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	1'466 kg 1,4-DB eq. /ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-3%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Pork Sample 20 (Alig et al. 2017) Remark:

Landscape	mix of hill and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact category	human tox incl. pesticides	**Relative difference per area and year (basis = conv)**	-92%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit conventional	0.07 kg 1,4-DB eq. / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CML01
Impact per product unit organic	<0.01 kg 1,4-DB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	163 kg 1,4-DB eq. / ha * y-1	**Productivity conventional**	2326 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	13 kg 1,4-DB eq. / ha * y-1	**Productivity organic**	1333 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	yes
Relative difference per product unit (basis = conv)	-86%	**Relative difference productivity (basis = conv)**	-43%	**Uncertainty analysis on results**	yes

Basset-Mens&van der Werf 2005 France

Data source: French official farm statistical data / expert judgment / data from one local feed producer

Pork Sample 21 (Basset-Mens&van der Werf 2005) Remark: inludes most metals, minerals, fossil fuels and uranium for nuclear powe

Landscape	low land	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact category	energy demand	**Relative difference per area and year (basis = conv)**	-23	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 1996
Impact per product unit conventional	15.9 MJ / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	SimaPro 1.1 method
Impact per product unit organic	22.2 MJ / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	29'272 MJ / ha * y-1	**Productivity conventional**	1841 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	22'511 MJ / ha * y-1	**Productivity organic**	1014 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	40	**Relative difference productivity (basis = conv)**	-45	**Uncertainty analysis on results**	yes

Pork Sample 22 (Basset-Mens&van der Werf 2005) Remark:

Landscape	low land	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-5	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 1996
Impact per product unit conventional	2.3 kg CO2 equ. / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	IPCC (1996) GWP 100
Impact per product unit organic	3.97 kg CO2 equ. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	4'234 kg CO2 equ. / ha * y-1	**Productivity conventional**	1841 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	4'026 kg CO2 equ. / ha * y-1	**Productivity organic**	1014 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	73	**Relative difference productivity (basis = conv)**	-45	**Uncertainty analysis on results**	yes

Pork Sample 23 (Basset-Mens&van der Werf 2005) Remark:

Landscape	low land	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact category	eutrophication potential	**Relative difference per area and year (basis = conv)**	-43	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 1996
Impact per product unit conventional	0.0208 kg PO43--equ / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CML02
Impact per product unit organic	0.0216 kg PO43--equ / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	38 kg PO43--equ /ha * y-1	**Productivity conventional**	1841 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	22 kg PO43--equ /ha * y-1	**Productivity organic**	1014 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	4	**Relative difference productivity (basis = conv)**	-45	**Uncertainty analysis on results**	yes

Pork Sample 24 (Basset-Mens&van der Werf 2005) Remark:

Landscape	low land	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact category	acidification	**Relative difference per area and year (basis = conv)**	-53	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 1996
Impact per product unit conventional	0.0435 kg SO2-equ./kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CML02
Impact per product unit organic	0.0372 kg SO2-equ./kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	80 kg SO2-equ./ha * y-1	**Productivity conventional**	1841 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	38 kg SO2-equ./ha * y-1	**Productivity organic**	1014 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	-14	**Relative difference productivity (basis = conv)**	-45	**Uncertainty analysis on results**	yes

Pork Sample 25 (Basset-Mens&van der Werf 2005) Remark:

Landscape	low land	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact category	pesticide use	**Relative difference per area and year (basis = conv)**	-90	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 1996
Impact per product unit conventional	0.00137 kg AI / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	LCI
Impact per product unit organic	0.000239 kg AI / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	3 kg AI /ha * y-1	**Productivity conventional**	1841 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	0 kg AI /ha * y-1	**Productivity organic**	1014 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	-83	**Relative difference productivity (basis = conv)**	-45	**Uncertainty analysis on results**	yes

Pork Sample 26 (Basset-Mens&van der Werf 2005) Remark:

Landscape	low land	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact category	land use	**Relative difference per area and year (basis = conv)**	0	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 1996
Impact per product unit conventional	5.43 m2 * y / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	LCI
Impact per product unit organic	9.87 m2 * y / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	9'997 m2 * y /ha * y-1	**Productivity conventional**	1841 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	10'008 m2 * y /ha * y-1	**Productivity organic**	1014 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	82	**Relative difference productivity (basis = conv)**	-45	**Uncertainty analysis on results**	yes

Pork Sample 27 (Basset-Mens&van der Werf 2005) Remark:

Landscape	low land	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact category	ecotox terrestrial	**Relative difference per area and year (basis = conv)**	1	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 1996
Impact per product unit conventional	0.0165 kg 1,4-DCB eq. / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CML02
Impact per product unit organic	0.0304 kg 1,4-DCB eq. / kg LW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	30 kg 1,4-DCB eq. / ha * y-1	**Productivity conventional**	1841 kg LW / ha	**Capital goods**	included
Impact per area and year conventional	31 kg 1,4-DCB eq. / ha * y-1	**Productivity organic**	1014 kg LW / ha	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	84	**Relative difference productivity (basis = conv)**	-45	**Uncertainty analysis on results**	yes

Williams et al. 2006 England & Wales

Data source: farm statistical data / database data / literature data / expert judgement

Pork Sample 28 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact category	energy demand	**Relative difference per area and year (basis = conv)**	-50%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit conventional	16.7 MJ/kg DW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	Cumulative energy demand
Impact per product unit organic	14.5 MJ/kg DW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	22'562 MJ/ha * y-1	**Productivity conventional**	1351 kg DW / ha	**Capital goods**	included
Impact per area and year conventional	11'325 MJ/ha * y-1	**Productivity organic**	781 kg DW / ha	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	-13%	**Relative difference productivity (basis = conv)**	-42%	**Uncertainty analysis on results**	no

Pork Sample 29 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-49%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit conventional	6.36 kg CO2-equ./kg DW * y-1	**Significant difference (area and year)?**	no testing	**Impact assessment method**	GWP100 (emission factors: CO2 = 1, CH4 = 23, N2O = 296)
Impact per product unit organic	5.64 kg CO2-equ./kg DW * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	8'592 kg CO2-equ./ha * y-1	**Productivity conventional**	1351 kg DW / ha	**Capital goods**	included
Impact per area and year conventional	4'405 kg CO2-equ./ha * y-1	**Productivity organic**	781 kg DW / ha	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	-11%	**Relative difference productivity (basis = conv)**	-42%	**Uncertainty analysis on results**	no

Pork Sample 30 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact category	eutrophication	**Relative difference per area and year (basis = conv)**	-67%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit conventional	0.1 kg PO43--equ / kg DW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	based on NO3, PO4 and NH3 emissions quantified in terms of phosphate equivalents (1 kg NO3-N = 0.44 kg PO4, 1 kg NH3-N = 0.43 kg PO4)
Impact per product unit organic	0.057 kg PO43--equ / kg DW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	135 kg PO43--equ / ha * y-1	**Productivity conventional**	1351 kg DW / ha	**Capital goods**	included
Impact per area and year conventional	45 kg PO43--equ / ha * y-1	**Productivity organic**	781 kg DW / ha	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	-43%	**Relative difference productivity (basis = conv)**	-42%	**Uncertainty analysis on results**	no

Pork Sample 31 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact category	acidification	**Relative difference per area and year (basis = conv)**	-81%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit conventional	0.395 kg SO2-equ./kg DW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	based on SO2 and NH3 emissions quantified in terms of SO2 equivalents (1 kg NH3-N = 2.3 kg SO2)
Impact per product unit organic	0.129 kg SO2-equ./kg DW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	534 kg SO2-equ./ha * y-1	**Productivity conventional**	1351 kg DW / ha	**Capital goods**	included
Impact per area and year conventional	101 kg SO2-equ./ha * y-1	**Productivity organic**	781 kg DW / ha	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	-67%	**Relative difference productivity (basis = conv)**	-42%	**Uncertainty analysis on results**	no

Pork Sample 32 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact category	pesticide use	**Relative difference per area and year (basis = conv)**	-100%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit conventional	88 m2 / kg DW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	Based on annual pesticide survey
Impact per product unit organic	0 m2 / kg DW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	118'888 m2 / ha * y-1	**Productivity conventional**	1351 kg DW / ha	**Capital goods**	included
Impact per area and year conventional	0 m2 / ha * y-1	**Productivity organic**	781 kg DW / ha	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	-100%	**Relative difference productivity (basis = conv)**	-42%	**Uncertainty analysis on results**	no

Pork Sample 33 (Williams et al. 2006) Remark:

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact category	land use	**Relative difference per area and year (basis = conv)**	-	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit conventional	7.4 m2 / kg DW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	yields were scaled on different grades of agricultural land
Impact per product unit organic	12.8 m2 / kg DW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	- m2 /ha * y-1	**Productivity conventional**	1351 kg DW / ha	**Capital goods**	included
Impact per area and year conventional	- m2 /ha * y-1	**Productivity organic**	781 kg DW / ha	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	73%	**Relative difference productivity (basis = conv)**	-42%	**Uncertainty analysis on results**	no

Pork Sample 34 (Williams et al. 2006) Remark: inludes most metals, minerals, fossil fuels and uranium for nuclear powe

Landscape	mix of hill, up and low land	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact category	abiotic resource use	**Relative difference per area and year (basis = conv)**	-45%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit conventional	0.035 kg Sb equiv. / kg DW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CML (unclear which version)
Impact per product unit organic	0.033 kg Sb equiv. / kg DW	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	47 kg Sb equiv. / ha * y-1	**Productivity conventional**	1351 kg DW / ha	**Capital goods**	included
Impact per area and year conventional	26 kg Sb equiv. / ha * y-1	**Productivity organic**	781 kg DW / ha	**Sensitivity analysis on choice of LCIA method**	no
Relative difference per product unit (basis = conv)	-6%	**Relative difference productivity (basis = conv)**	-42%	**Uncertainty analysis on results**	no

Alig et al. 2012 CH

Data source: model farms based on data from meat industry

Poultry and Egg Sample 1 (Alig et al. 2012) Remark:

Impact category	energy demand	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	17.3 MJ / kg LW	**Relative difference per area and year (basis = conv)**	-32%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	26.9 MJ / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CED (ecoinvent)
Impact per area and year conventional	78'629 MJ / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	53'800 MJ / ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	55%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 2 (Alig et al. 2012) Remark:

Impact category	GWP	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	1.6 kg CO2 equ. / kg LW	**Relative difference per area and year (basis = conv)**	-42%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	2.1 kg CO2 equ. / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	IPCC 2006
Impact per area and year conventional	7'272 kg CO2 equ. /ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	4'200 kg CO2 equ. /ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	31%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 3 (Alig et al. 2012) Remark:

Impact category	Ozon vegetation	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	11.2 m2.ppm.h / kg LW	**Relative difference per area and year (basis = conv)**	-48%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	13.2 m2.ppm.h / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	EDIP03
Impact per area and year conventional	50'904 m2.ppm.h /ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no (global)
Impact per area and year conventional	26'400 m2.ppm.h /ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	18%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 4 (Alig et al. 2012) Remark:

Impact category	ozon human	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.001 person.ppm.h / kg LW	**Relative difference per area and year (basis = conv)**	-56%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	0.001 person.ppm.h / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	EDIP03
Impact per area and year conventional	5 person.ppm.h /ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no (global)
Impact per area and year conventional	2 person.ppm.h /ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	0%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 5 (Alig et al. 2012) Remark:

Impact category	resource use P	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.0051 kg / kg LW	**Relative difference per area and year (basis = conv)**	-85%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	0.0017 kg / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	LCI
Impact per area and year conventional	23 kg /ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	3 kg /ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	-67%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 6 (Alig et al. 2012) Remark:

Impact category	resource use K	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.0065 kg / kg LW	**Relative difference per area and year (basis = conv)**	-99%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	0.0002 kg / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	LCI
Impact per area and year conventional	30 kg /ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	0 kg /ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	-97%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 7 (Alig et al. 2012) Remark:

Impact category	land use	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	2.2 m2*a / kg LW	**Relative difference per area and year (basis = conv)**	-	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	5 m2*a / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CLM01
Impact per area and year conventional	- m2*a /ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	- m2*a /ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	127%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 8 (Alig et al. 2012) Remark:

Impact category	arable land use	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	2.1 m2*a / kg LW	**Relative difference per area and year (basis = conv)**	-2%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	4.7 m2*a / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CLM01
Impact per area and year conventional	9'545 m2*a / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	9'400 m2*a / ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	124%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 9 (Alig et al. 2012) Remark:

Impact category	deforested land use	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.0012 m2 / kg LW	**Relative difference per area and year (basis = conv)**	-93%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	0.0002 m2 / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	LCI
Impact per area and year conventional	5 m2 / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	0 m2 / ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	-83%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 10 (Alig et al. 2012) Remark:

Impact category	water use	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.158 m3 / kg LW	**Relative difference per area and year (basis = conv)**	-93%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	0.024 m3 / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	LCI
Impact per area and year conventional	718 m3 / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	48 m3 / ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	-85%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 11 (Alig et al. 2012) Remark:

Impact category	eutrophication potential terrestric	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.5 m2 / kg LW	**Relative difference per area and year (basis = conv)**	6%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	1.2 m2 / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	EDIP 2003
Impact per area and year conventional	2'273 m2 / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no (global)
Impact per area and year conventional	2'400 m2 / ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	140%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 12 (Alig et al. 2012) Remark:

Impact category	eutrophication potential aquatic N	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.01 kg N / kg LW	**Relative difference per area and year (basis = conv)**	-12%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	0.02 kg N / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	EDIP 2003
Impact per area and year conventional	45 kg N / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no (global)
Impact per area and year conventional	40 kg N / ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	100%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 13 (Alig et al. 2012) Remark:

Impact category	eutrophication potential aquatic P	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.0003 kg P / kg LW	**Relative difference per area and year (basis = conv)**	-56%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	0.0003 kg P / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	EDIP 2003
Impact per area and year conventional	1 kg P / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no (global)
Impact per area and year conventional	1 kg P / ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	0%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 14 (Alig et al. 2012) Remark:

Impact category	acidification potential	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.2 m2	**Relative difference per area and year (basis = conv)**	-12%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	0.4 m2	**Significant difference (area and year)?**	no testing	**Impact assessment method**	EDIP03
Impact per area and year conventional	909 m2	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no (global)
Impact per area and year conventional	800 m2	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	100%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 15 (Alig et al. 2012) Remark:

Impact category	ecotox terrestrial without pesticides	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.0021 kg 1,4-DB eq. / kg LW	**Relative difference per area and year (basis = conv)**	11%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2007
Impact per product unit organic	0.0053 kg 1,4-DB eq. / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CML01
Impact per area and year conventional	10 kg 1,4-DB eq. / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	11 kg 1,4-DB eq. / ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	152%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 16 (Alig et al. 2012) Remark:

Impact category	ecotox terrestrial incl. pesticides	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.0043 kg 1,4-DB eq. / kg LW	**Relative difference per area and year (basis = conv)**	-99%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2007
Impact per product unit organic	0.0001 kg 1,4-DB eq. / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CML01
Impact per area and year conventional	20 kg 1,4-DB eq. / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	0 kg 1,4-DB eq. / ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	-98%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 17 (Alig et al. 2012) Remark:

Impact category	ecotox aquatic without pesticides	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.023 kg 1,4-DB eq. / kg LW	**Relative difference per area and year (basis = conv)**	-52%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2007
Impact per product unit organic	0.025 kg 1,4-DB eq. / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CML01
Impact per area and year conventional	105 kg 1,4-DB eq. / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	50 kg 1,4-DB eq. / ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	9%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 18 (Alig et al. 2012) Remark:

Impact category	ecotox aquatic incl. pesticides	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.145 kg 1,4-DB eq. / kg LW	**Relative difference per area and year (basis = conv)**	-100%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2007
Impact per product unit organic	0.001 kg 1,4-DB eq. / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CML01
Impact per area and year conventional	659 kg 1,4-DB eq. / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	2 kg 1,4-DB eq. / ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	-99%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 19 (Alig et al. 2012) Remark:

Impact category	human tox without pesticides	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.42 kg 1,4-DB eq. / kg LW	**Relative difference per area and year (basis = conv)**	-35%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2007
Impact per product unit organic	0.62 kg 1,4-DB eq. / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CML01
Impact per area and year conventional	1'909 kg 1,4-DB eq. /ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	1'240 kg 1,4-DB eq. /ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	48%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 20 (Alig et al. 2012) Remark:

Impact category	human tox incl. pesticides	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.06 kg 1,4-DB eq. / kg LW	**Relative difference per area and year (basis = conv)**	-93%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2007
Impact per product unit organic	<0.01 kg 1,4-DB eq. / kg LW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CML01
Impact per area and year conventional	273 kg 1,4-DB eq. / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	characterization factors according Hayer et al. (2009)
Impact per area and year conventional	20 kg 1,4-DB eq. / ha * y-1	**Productivity conventional**	4545 kg LW/ ha * y-1	**Capital goods**	included
Relative difference per product unit (basis = conv)	-83%	**Productivity organic**	2000 kg LW/ ha * y-1	**Sensitivity analysis on choice of LCIA method**	yes
		Relative difference productivity (basis = conv)	-56%	**Uncertainty analysis on results**	yes

Boggia et al. 2010 Italy

Data source: primary data assessed on 1 organic and 1 conventional farm

Poultry and Egg Sample 21 (Boggia et al. 2010) Remark:

Impact category	GWP	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	1.6e-005 Pt / kg poultry meat	**Relative difference per area and year (basis = conv)**	-68%	**Calculation basis for N2O-emissions from soils and manure storag**	
Impact per product unit organic	1.22e-005 Pt / kg poultry meat	**Significant difference (area and year)?**	no testing	**Impact assessment method**	Eco-Indicator 99
Impact per area and year conventional	422 Pt / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	136 Pt / ha * y-1	**Productivity conventional**	26385224 Pt / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	-24%	**Productivity organic**	11160714 Pt / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-58%	**Uncertainty analysis on results**	no

Poultry and Egg Sample 22 (Boggia et al. 2010) Remark:

Impact category	Acidification / Eutrophication potential	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	3.64e-005 Pt / kg poultry meat	**Relative difference per area and year (basis = conv)**	-51%	**Calculation basis for N2O-emissions from soils and manure storag**	
Impact per product unit organic	4.24e-005 Pt / kg poultry meat	**Significant difference (area and year)?**	no testing	**Impact assessment method**	Eco-Indicator 99
Impact per area and year conventional	960 Pt / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	473 Pt / ha * y-1	**Productivity conventional**	26385224 Pt / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	16%	**Productivity organic**	11160714 Pt / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-58%	**Uncertainty analysis on results**	no

Poultry and Egg Sample 23 (Boggia et al. 2010) Remark:

Impact category	land use	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	0.000379 Pt / kg poultry meat	**Relative difference per area and year (basis = conv)**	-0%	**Calculation basis for N2O-emissions from soils and manure storag**	
Impact per product unit organic	0.000896 Pt / kg poultry meat	**Significant difference (area and year)?**	no testing	**Impact assessment method**	Eco-Indicator 99
Impact per area and year conventional	10'000 Pt / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	10'000 Pt / ha * y-1	**Productivity conventional**	26385224 Pt / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	136%	**Productivity organic**	11160714 Pt / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-58%	**Uncertainty analysis on results**	no

Poultry and Egg Sample 24 (Boggia et al. 2010) Remark:

Impact category	energy demand	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	0.000201 Pt / kg poultry meat	**Relative difference per area and year (basis = conv)**	-56%	**Calculation basis for N2O-emissions from soils and manure storag**	
Impact per product unit organic	0.000207 Pt / kg poultry meat	**Significant difference (area and year)?**	no testing	**Impact assessment method**	Eco-Indicator 99
Impact per area and year conventional	5'303 Pt / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	2'310 Pt / ha * y-1	**Productivity conventional**	26385224 Pt / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	3%	**Productivity organic**	11160714 Pt / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-58%	**Uncertainty analysis on results**	no

Poultry and Egg Sample 25 (Boggia et al. 2010) Remark:

Impact category	Carcinogens	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	3.05e-006 Pt / kg poultry meat	**Relative difference per area and year (basis = conv)**	-68%	**Calculation basis for N2O-emissions from soils and manure storag**	
Impact per product unit organic	2.3e-006 Pt / kg poultry meat	**Significant difference (area and year)?**	no testing	**Impact assessment method**	Eco-Indicator 99
Impact per area and year conventional	80 Pt / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	26 Pt / ha * y-1	**Productivity conventional**	26385224 Pt / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	-25%	**Productivity organic**	11160714 Pt / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-58%	**Uncertainty analysis on results**	no

Poultry and Egg Sample 26 (Boggia et al. 2010) Remark:

Impact category	Resp. organics	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	1.08e-007 Pt / kg poultry meat	**Relative difference per area and year (basis = conv)**	-65%	**Calculation basis for N2O-emissions from soils and manure storag**	
Impact per product unit organic	9.06e-008 Pt / kg poultry meat	**Significant difference (area and year)?**	no testing	**Impact assessment method**	Eco-Indicator 99
Impact per area and year conventional	3 Pt / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	1 Pt / ha * y-1	**Productivity conventional**	26385224 Pt / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	-16%	**Productivity organic**	11160714 Pt / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-58%	**Uncertainty analysis on results**	no

Poultry and Egg Sample 27 (Boggia et al. 2010) Remark:

Impact category	Resp. inorganics	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	0.000138 Pt / kg poultry meat	**Relative difference per area and year (basis = conv)**	-67%	**Calculation basis for N2O-emissions from soils and manure storag**	
Impact per product unit organic	0.000107 Pt / kg poultry meat	**Significant difference (area and year)?**	no testing	**Impact assessment method**	Eco-Indicator 99
Impact per area and year conventional	3'641 Pt / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	1'194 Pt / ha * y-1	**Productivity conventional**	26385224 Pt / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	-22%	**Productivity organic**	11160714 Pt / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-58%	**Uncertainty analysis on results**	no

Poultry and Egg Sample 28 (Boggia et al. 2010) Remark:

Impact category	Radiation	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	1.03e-007 Pt / kg poultry meat	**Relative difference per area and year (basis = conv)**	-49%	**Calculation basis for N2O-emissions from soils and manure storag**	
Impact per product unit organic	1.24e-007 Pt / kg poultry meat	**Significant difference (area and year)?**	no testing	**Impact assessment method**	Eco-Indicator 99
Impact per area and year conventional	3 Pt / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	1 Pt / ha * y-1	**Productivity conventional**	26385224 Pt / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	20%	**Productivity organic**	11160714 Pt / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-58%	**Uncertainty analysis on results**	no

Poultry and Egg Sample 29 (Boggia et al. 2010) Remark:

Impact category	Ozone layer depletion	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	6.78e-009 Pt / kg poultry meat	**Relative difference per area and year (basis = conv)**	-60%	**Calculation basis for N2O-emissions from soils and manure storag**	
Impact per product unit organic	6.37e-009 Pt / kg poultry meat	**Significant difference (area and year)?**	no testing	**Impact assessment method**	Eco-Indicator 99
Impact per area and year conventional	0 Pt / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	0 Pt / ha * y-1	**Productivity conventional**	26385224 Pt / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	-6%	**Productivity organic**	11160714 Pt / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-58%	**Uncertainty analysis on results**	no

Poultry and Egg Sample 30 (Boggia et al. 2010) Remark:

Impact category	Ecotox.	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	1.79e-005 Pt / kg poultry meat	**Relative difference per area and year (basis = conv)**	-65%	**Calculation basis for N2O-emissions from soils and manure storag**	
Impact per product unit organic	1.49e-005 Pt / kg poultry meat	**Significant difference (area and year)?**	no testing	**Impact assessment method**	Eco-Indicator 99
Impact per area and year conventional	472 Pt / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	166 Pt / ha * y-1	**Productivity conventional**	26385224 Pt / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	-17%	**Productivity organic**	11160714 Pt / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-58%	**Uncertainty analysis on results**	no

Poultry and Egg Sample 31 (Boggia et al. 2010) Remark:

Impact category	Resource use: Minerals	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	7.06e-006 Pt / kg poultry meat	**Relative difference per area and year (basis = conv)**	-65%	**Calculation basis for N2O-emissions from soils and manure storag**	
Impact per product unit organic	5.88e-006 Pt / kg poultry meat	**Significant difference (area and year)?**	no testing	**Impact assessment method**	Eco-Indicator 99
Impact per area and year conventional	186 Pt / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	66 Pt / ha * y-1	**Productivity conventional**	26385224 Pt / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	-17%	**Productivity organic**	11160714 Pt / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-58%	**Uncertainty analysis on results**	no

Leinonen et al. 2012a UK

Data source: industry data / national inventories / database data

Poultry and Egg Sample 32 (Leinonen et al. 2012a) Remark: Conventional = Standard egg production

Impact category	Energy demand	**Significant difference (product unit)?**	P < 0.05	**ILUC included**	included
Impact per product unit conventional	25.37 MJ / kg CW	**Relative difference per area and year (basis = conv)**	-64%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	40.34 MJ / kg CW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	as in Williams et al. (2006)
Impact per area and year conventional	45'311 MJ / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	16'136 MJ / ha * y-1	**Productivity conventional**	1'786 kg CW/ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	59%	**Productivity organic**	400 kg CW/ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-78%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 33 (Leinonen et al. 2012a) Remark: Conventional = Standard egg production

Impact category	GWP	**Significant difference (product unit)?**	P < 0.05	**ILUC included**	included
Impact per product unit conventional	4.41 kg CO2-eq./kg CW	**Relative difference per area and year (basis = conv)**	-71%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	5.66 kg CO2-eq./kg CW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	as in Williams et al. (2006)
Impact per area and year conventional	7'876 kg CO2-eq./ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	2'264 kg CO2-eq./ha * y-1	**Productivity conventional**	1'786 kg CW/ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	28%	**Productivity organic**	400 kg CW/ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-78%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 34 (Leinonen et al. 2012a) Remark: Conventional = Standard egg production

Impact category	Eutrophication potential	**Significant difference (product unit)?**	P < 0.05	**ILUC included**	included
Impact per product unit conventional	0.02031 kg PO43--eq. / kg CW	**Relative difference per area and year (basis = conv)**	-46%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	0.04882 kg PO43--eq. / kg CW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	as in Williams et al. (2006)
Impact per area and year conventional	36 kg PO43--eq. /ha *y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	20 kg PO43--eq. /ha *y-1	**Productivity conventional**	1'786 kg CW/ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	140%	**Productivity organic**	400 kg CW/ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-78%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 35 (Leinonen et al. 2012a) Remark: Conventional = Standard egg production

Impact category	Acidification potential	**Significant difference (product unit)?**	P < 0.05	**ILUC included**	included
Impact per product unit conventional	0.04675 kg SO2-eq./kg CW	**Relative difference per area and year (basis = conv)**	-56%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	0.09155 kg SO2-eq./kg CW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	as in Williams et al. (2006)
Impact per area and year conventional	83 kg SO2-eq./ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	37 kg SO2-eq./ha * y-1	**Productivity conventional**	1'786 kg CW/ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	96%	**Productivity organic**	400 kg CW/ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-78%	**Uncertainty analysis on results**	yes

8.4 RAW DATA POULTRY AND EGG

Poultry and Egg Sample 36 (Leinonen et al. 2012a) Remark: Conventional = Standard egg production

Impact category	Pesticide use	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.00277 dose-ha/kg CW	**Relative difference per area and year (basis = conv)**	-98%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	0.00029 dose-ha/kg CW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	as in Williams et al. (2006)
Impact per area and year conventional	5 dose-ha/ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	0 dose-ha/ha * y-1	**Productivity conventional**	1'786 kg CW/ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	-90%	**Productivity organic**	400 kg CW/ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-78%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 37 (Leinonen et al. 2012a) Remark: Conventional = Standard egg production

Impact category	Abiotic resource use	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.0189 kg Sb eq. / kg CW	**Relative difference per area and year (basis = conv)**	-60%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	0.034 kg Sb eq. / kg CW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	as in Williams et al. (2006)
Impact per area and year conventional	34 kg Sb eq. /ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	14 kg Sb eq. /ha * y-1	**Productivity conventional**	1'786 kg CW/ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	80%	**Productivity organic**	400 kg CW/ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-78%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 38 (Leinonen et al. 2012a) Remark: Conventional = Standard egg production

Impact category	land use	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	5.6 m2/kg CW	**Relative difference per area and year (basis = conv)**	-	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	25 m2/kg CW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	as in Williams et al. (2006)
Impact per area and year conventional	- m2/ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	- m2/ha * y-1	**Productivity conventional**	1'786 kg CW/ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	346%	**Productivity organic**	400 kg CW/ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-78%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 39 (Leinonen et al. 2012b) Remark: Conventional = Cage egg production

Impact category	Energy demand	**Significant difference (product unit)?**	P < 0.05	**ILUC included**	included
Impact per product unit conventional	16.88 MJ / kg eggs	**Relative difference per area and year (basis = conv)**	-63%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	26.41 MJ / kg eggs	**Significant difference (area and year)?**	no testing	**Impact assessment method**	as in Williams et al. (2006)
Impact per area and year conventional	42'200 MJ / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	15'635 MJ / ha * y-1	**Productivity conventional**	2'500 kg eggs/ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	56%	**Productivity organic**	592 kg eggs/ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-76%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 40 (Leinonen et al. 2012b) Remark: Conventional = Cage egg production

Impact category	GWP	**Significant difference (product unit)?**	P < 0.05	**ILUC included**	included
Impact per product unit conventional	2.92 kg CO2-eq./kg eggs	**Relative difference per area and year (basis = conv)**	-72%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	3.42 kg CO2-eq./kg eggs	**Significant difference (area and year)?**	no testing	**Impact assessment method**	as in Williams et al. (2006)
Impact per area and year conventional	7'300 kg CO2-eq./ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	2'025 kg CO2-eq./ha * y-1	**Productivity conventional**	2'500 kg eggs/ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	17%	**Productivity organic**	592 kg eggs/ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-76%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 41 (Leinonen et al. 2012b) Remark: Conventional = Cage egg production

Impact category	Eutrophication potential	**Significant difference (product unit)?**	P < 0.05	**ILUC included**	included
Impact per product unit conventional	0.01847 kg PO43--eq. / kg eggs	**Relative difference per area and year (basis = conv)**	-52%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	0.03761 kg PO43--eq. / kg eggs	**Significant difference (area and year)?**	no testing	**Impact assessment method**	as in Williams et al. (2006)
Impact per area and year conventional	46 kg PO43--eq. /ha *y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	22 kg PO43--eq. /ha *y-1	**Productivity conventional**	2'500 kg eggs/ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	104%	**Productivity organic**	592 kg eggs/ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-76%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 42 (Leinonen et al. 2012b) Remark: Conventional = Cage egg production

Impact category	Acidification potential	**Significant difference (product unit)?**	P < 0.05	**ILUC included**	included
Impact per product unit conventional	0.05314 kg SO2-eq./kg eggs	**Relative difference per area and year (basis = conv)**	-59%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	0.09163 kg SO2-eq./kg eggs	**Significant difference (area and year)?**	no testing	**Impact assessment method**	as in Williams et al. (2006)
Impact per area and year conventional	133 kg SO2-eq./ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	54 kg SO2-eq./ha * y-1	**Productivity conventional**	2'500 kg eggs/ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	72%	**Productivity organic**	592 kg eggs/ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-76%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 43 (Leinonen et al. 2012b) Remark: Conventional = Cage egg production

Impact category	Pesticide use	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.00207 dose-ha/kg eggs	**Relative difference per area and year (basis = conv)**	-99%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	9e-005 dose-ha/kg eggs	**Significant difference (area and year)?**	no testing	**Impact assessment method**	as in Williams et al. (2006)
Impact per area and year conventional	5 dose-ha/ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	0 dose-ha/ha * y-1	**Productivity conventional**	2'500 kg eggs/ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	-96%	**Productivity organic**	592 kg eggs/ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-76%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 44 (Leinonen et al. 2012b) Remark: Conventional = Cage egg production

Impact category	Abiotic resource use	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	0.00911 kg Sb eq. / kg eggs	**Relative difference per area and year (basis = conv)**	-47%	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	0.02025 kg Sb eq. / kg eggs	**Significant difference (area and year)?**	no testing	**Impact assessment method**	as in Williams et al. (2006)
Impact per area and year conventional	23 kg Sb eq. /ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	12 kg Sb eq. /ha * y-1	**Productivity conventional**	2'500 kg eggs/ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	122%	**Productivity organic**	592 kg eggs/ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-76%	**Uncertainty analysis on results**	yes

Poultry and Egg Sample 45 (Leinonen et al. 2012b) Remark: Conventional = Cage egg production

Impact category	land use	**Significant difference (product unit)?**	no testing	**ILUC included**	included
Impact per product unit conventional	4.0 m2/kg eggs	**Relative difference per area and year (basis = conv)**	-	**Calculation basis for N2O-emissions from soils and manure storag**	IPCC 2006
Impact per product unit organic	16.9 m2/kg eggs	**Significant difference (area and year)?**	no testing	**Impact assessment method**	as in Williams et al. (2006)
Impact per area and year conventional	- m2/ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	no
Impact per area and year conventional	- m2/ha * y-1	**Productivity conventional**	2'500 kg eggs/ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	322%	**Productivity organic**	592 kg eggs/ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-76%	**Uncertainty analysis on results**	yes

Williams et al. 2006 England & Wales

Data source: farm statistical data / database data / literature data / expert judgement

Poultry and Egg Sample 46 (Williams et al. 2006) Remark:

Impact category	energy demand	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	12 MJ/kg DW	**Relative difference per area and year (basis = conv)**	-40%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit organic	15.8 MJ/kg DW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	Cumulative energy demand
Impact per area and year conventional	18'756 MJ/ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	11'281 MJ/ha * y-1	**Productivity conventional**	1563 kg DW / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	32%	**Productivity organic**	714 kg DW / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-54	**Uncertainty analysis on results**	no

Poultry and Egg Sample 47 (Williams et al. 2006) Remark:

Impact category	GWP	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	4.57 kg CO2-eq./kg DW	**Relative difference per area and year (basis = conv)**	-33%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit organic	6.68 kg CO2-eq./kg DW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	GWP100 (emission factors: CO2 = 1, CH4 = 23, N2O = 296)
Impact per area and year conventional	7'143 kg CO2-eq./ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	4'770 kg CO2-eq./ha * y-1	**Productivity conventional**	1563 kg DW / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	46%	**Productivity organic**	714 kg DW / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-54	**Uncertainty analysis on results**	no

Poultry and Egg Sample 48 (Williams et al. 2006) Remark:

Impact category	eutrophication potential	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	0.049 kg PO43--eq. / kg DW	**Relative difference per area and year (basis = conv)**	-20%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit organic	0.086 kg PO43--eq. / kg DW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	based on NO3, PO4 and NH3 emissions quantified in terms of phosphate equivalents (1 kg NO3-N = 0.44 kg PO4, 1 kg NH3-N = 0.43 kg PO4)
Impact per area and year conventional	77 kg PO43--eq./ ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	61 kg PO43--eq./ ha * y-1	**Productivity conventional**	1563 kg DW / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	76%	**Productivity organic**	714 kg DW / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-54	**Uncertainty analysis on results**	no

Poultry and Egg Sample 49 (Williams et al. 2006) Remark:

Impact category	acidification potential	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	0.173 kg SO2-eq./kg DW	**Relative difference per area and year (basis = conv)**	-30%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit organic	0.264 kg SO2-eq./kg DW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	based on SO2 and NH3 emissions quantified in terms of SO2 equivalents (1 kg NH3-N = 2.3 kg SO2)
Impact per area and year conventional	270 kg SO2-eq./ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	188 kg SO2-eq./ha * y-1	**Productivity conventional**	1563 kg DW / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	53%	**Productivity organic**	714 kg DW / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-54	**Uncertainty analysis on results**	no

Poultry and Egg Sample 50 (Williams et al. 2006) Remark:

Impact category	pesticide use	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	77 m2 / kg DW	**Relative difference per area and year (basis = conv)**	-96%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit organic	6 m2 / kg DW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	Based on annual pesticide survey
Impact per area and year conventional	120'351 m2 / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	4'284 m2 / ha * y-1	**Productivity conventional**	1563 kg DW / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	-92%	**Productivity organic**	714 kg DW / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-54	**Uncertainty analysis on results**	no

Poultry and Egg Sample 51 (Williams et al. 2006) Remark:

Impact category	land use	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	6.4 m2 / kg DW	**Relative difference per area and year (basis = conv)**	-	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit organic	14 m2 / kg DW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	yields were scaled on different grades of agricultural land
Impact per area and year conventional	- m2 / ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	- m2 / ha * y-1	**Productivity conventional**	1563 kg DW / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	119%	**Productivity organic**	714 kg DW / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-54	**Uncertainty analysis on results**	no

Poultry and Egg Sample 52 (Williams et al. 2006) Remark: inludes most metals, minerals, fossil fuels and uranium for nuclear powe

Impact category	abiotic resource use	**Significant difference (product unit)?**	no testing	**ILUC included**	not included
Impact per product unit conventional	0.029 kg Sb eq. / kg DW	**Relative difference per area and year (basis = conv)**	56%	**Calculation basis for N2O-emissions from soils and manure storag**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact per product unit organic	0.099 kg Sb eq. / kg DW	**Significant difference (area and year)?**	no testing	**Impact assessment method**	CML (unclear which version)
Impact per area and year conventional	45 kg Sb eq./ha * y-1	**Life cylce system boundary**	cradle to farm gate	**Site specific emission- and characterization factors used**	
Impact per area and year conventional	71 kg Sb eq./ha * y-1	**Productivity conventional**	1563 kg DW / ha	**Capital goods**	included
Relative difference per product unit (basis = conv)	241%	**Productivity organic**	714 kg DW / ha	**Sensitivity analysis on choice of LCIA method**	no
		Relative difference productivity (basis = conv)	-54	**Uncertainty analysis on results**	no

Abeliotis et al. 2013 Greece

Data source: several producers involved in a labbeling schemes (to derive average agricultural practice in the region under study)

Arable Crops Sample 1 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Gigantes)	**Relative difference per product unit (basis = conv)**	-27%	**Relative difference productivity (basis = conv)**	12%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	abiotic resource use	**Relative difference per area and year (basis = conv)**	-19%	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.000732 kg antimony eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.000532 kg antimony eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	2.0 kg antimony eq./ha	**Productivity conventional**	2'800 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	1.7 kg antimony eq./ha	**Productivity organic**	3'130 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 2 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Gigantes)	**Relative difference per product unit (basis = conv)**	23%	**Relative difference productivity (basis = conv)**	12%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	GWP	**Relative difference per area and year (basis = conv)**	37%	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.247 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.303 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	692 kg CO2 eq./ha	**Productivity conventional**	2'800 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	948 kg CO2 eq./ha	**Productivity organic**	3'130 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 3 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Gigantes)	**Relative difference per product unit (basis = conv)**	11%	**Relative difference productivity (basis = conv)**	12%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	Ozone depletion	**Relative difference per area and year (basis = conv)**	24%	**Impact assessment method**	CML 2000
Impact per product unit conventional	4.74e-009 kg CFC-11 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	5.24E-09 kg CFC-11 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	0.000013 kg CFC-11 eq./ha	**Productivity conventional**	2'800 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0.000016 kg CFC-11 eq./ha	**Productivity organic**	3'130 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 4 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Gigantes)	**Relative difference per product unit (basis = conv)**	-2%	**Relative difference productivity (basis = conv)**	12%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	Human tox	**Relative difference per area and year (basis = conv)**	10%	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.00994 kg 1,4-DB eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.00979 kg 1,4-DB eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	27.8 kg 1,4-DB eq./ha	**Productivity conventional**	2'800 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	30.6 kg 1,4-DB eq./ha	**Productivity organic**	3'130 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 5 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Gigantes)	**Relative difference per product unit (basis = conv)**	-0.06%	**Relative difference productivity (basis = conv)**	12%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	Ecotox aquatic (freshwater)	**Relative difference per area and year (basis = conv)**	-252%	**Impact assessment method**	CML 2000
Impact per product unit conventional	-0.0001 kg 1,4-DB eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	-0.000668 kg 1,4-DB eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	-0.3 kg 1,4-DB eq./ha	**Productivity conventional**	2'800 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	-2.1 kg 1,4-DB eq./ha	**Productivity organic**	3'130 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 6 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Gigantes)	**Relative difference per product unit (basis = conv)**	10%	**Relative difference productivity (basis = conv)**	12%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	Ecotox aquatic (marine)	**Relative difference per area and year (basis = conv)**	23%	**Impact assessment method**	CML 2000
Impact per product unit conventional	40 kg 1,4-DB eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	44 kg 1,4-DB eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	112001 kg 1,4-DB eq./ha	**Productivity conventional**	2'800 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	137719 kg 1,4-DB eq./ha	**Productivity organic**	3'130 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 7 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Gigantes)	**Relative difference per product unit (basis = conv)**	8%	**Relative difference productivity (basis = conv)**	12%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	Ecotox terrestrial	**Relative difference per area and year (basis = conv)**	21%	**Impact assessment method**	CML 2000
Impact per product unit conventional	1.28E-04 kg 1,4-DB eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	1.38E-04 kg 1,4-DB eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	0.36 kg 1,4-DB eq./ha	**Productivity conventional**	2'800 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0.43 kg 1,4-DB eq./ha	**Productivity organic**	3'130 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 8 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Gigantes)	**Relative difference per product unit (basis = conv)**	-28%	**Relative difference productivity (basis = conv)**	12%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	Photochemical oxidation	**Relative difference per area and year (basis = conv)**	-19%	**Impact assessment method**	CML 2000
Impact per product unit conventional	1.25E-05 mg C2H4 eq. /kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	9.03E-06 mg C2H4 eq. /kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	0.04 mg C2H4 eq./ha	**Productivity conventional**	2'800 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0.03 mg C2H4 eq./ha	**Productivity organic**	3'130 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 9 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Gigantes)	**Relative difference per product unit (basis = conv)**	24%	**Relative difference productivity (basis = conv)**	12%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	Acidification	**Relative difference per area and year (basis = conv)**	39%	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.0132 kg SO2 eq. /kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.0164 kg SO2 eq. /kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	37.0 kg SO2 eq./ha	**Productivity conventional**	2'800 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	51.3 kg SO2 eq./ha	**Productivity organic**	3'130 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 10 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Gigantes)	**Relative difference per product unit (basis = conv)**	19%	**Relative difference productivity (basis = conv)**	12%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	Eutrophication	**Relative difference per area and year (basis = conv)**	33%	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.0022 kg PO43- eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.00261 kg PO43- eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	6.2 kg PO43- eq./ha	**Productivity conventional**	2'800 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	8.2 kg PO43- eq./ha	**Productivity organic**	3'130 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 11 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Plake)	**Relative difference per product unit (basis = conv)**	-83%	**Relative difference productivity (basis = conv)**	32%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	abiotic resource use	**Relative difference per area and year (basis = conv)**	-77%	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.000866 kg antimony eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.000151 kg antimony eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	0.9959 kg antimony eq./ha	**Productivity conventional**	1'150 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0.22952 kg antimony eq./ha	**Productivity organic**	1'520 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 12 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Plake)	**Relative difference per product unit (basis = conv)**	45%	**Relative difference productivity (basis = conv)**	32%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	GWP	**Relative difference per area and year (basis = conv)**	92%	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.302 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.438 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	347.3 kg CO2 eq./ha	**Productivity conventional**	1'150 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	665.76 kg CO2 eq./ha	**Productivity organic**	1'520 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 13 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Plake)	**Relative difference per product unit (basis = conv)**	0%	**Relative difference productivity (basis = conv)**	32%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	Ozone depletion	**Relative difference per area and year (basis = conv)**	32%	**Impact assessment method**	CML 2000
Impact per product unit conventional	5.74E-09 kg CFC-11 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	5.75E-09 kg CFC-11 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	6.601e-006 kg CFC-11 eq./ha	**Productivity conventional**	1'150 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	8.74e-006 kg CFC-11 eq./ha	**Productivity organic**	1'520 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 14 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Plake)	**Relative difference per product unit (basis = conv)**	-12%	**Relative difference productivity (basis = conv)**	32%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	Human tox	**Relative difference per area and year (basis = conv)**	17%	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.012 kg 1,4-DB eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.0106 kg 1,4-DB eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	13.8 kg 1,4-DB eq./ha	**Productivity conventional**	1'150 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	16.112 kg 1,4-DB eq./ha	**Productivity organic**	1'520 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 15 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Plake)	**Relative difference per product unit (basis = conv)**	0.03%	**Relative difference productivity (basis = conv)**	32%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	Ecotox aquatic (freshwater)	**Relative difference per area and year (basis = conv)**	38%	**Impact assessment method**	CML 2000
Impact per product unit conventional	-1.17E-05 kg 1,4-DB eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.000263 kg 1,4-DB eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	-0.013455 kg 1,4-DB eq./ha	**Productivity conventional**	1'150 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0.39976 kg 1,4-DB eq./ha	**Productivity organic**	1'520 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 16 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Plake)	**Relative difference per product unit (basis = conv)**	-2%	**Relative difference productivity (basis = conv)**	32%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	Ecotox aquatic (marine)	**Relative difference per area and year (basis = conv)**	29%	**Impact assessment method**	CML 2000
Impact per product unit conventional	48.4 kg 1,4-DB eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	47.4 kg 1,4-DB eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	55660 kg 1,4-DB eq./ha	**Productivity conventional**	1'150 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	72048 kg 1,4-DB eq./ha	**Productivity organic**	1'520 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 17 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Plake)	**Relative difference per product unit (basis = conv)**	-5%	**Relative difference productivity (basis = conv)**	32%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	Ecotox terrestrial	**Relative difference per area and year (basis = conv)**	25%	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.000155 kg 1,4-DB eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.000147 kg 1,4-DB eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	0.17825 kg 1,4-DB eq./ha	**Productivity conventional**	1'150 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0.22344 kg 1,4-DB eq./ha	**Productivity organic**	1'520 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 18 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Plake)	**Relative difference per product unit (basis = conv)**	-93%	**Relative difference productivity (basis = conv)**	32%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	Photochemical oxidation	**Relative difference per area and year (basis = conv)**	-91%	**Impact assessment method**	CML 2000
Impact per product unit conventional	1.46E-05 mg C2H4 eq. /kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	9.87E-07 mg C2H4 eq. /kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	0.01679 mg C2H4 eq./ha	**Productivity conventional**	1'150 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0.00150024 mg C2H4 eq./ha	**Productivity organic**	1'520 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 19 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Plake)	**Relative difference per product unit (basis = conv)**	66%	**Relative difference productivity (basis = conv)**	32%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	Acidification	**Relative difference per area and year (basis = conv)**	119%	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.0162 kg SO2 eq. /kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.0269 kg SO2 eq. /kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	18.63 kg SO2 eq./ha	**Productivity conventional**	1'150 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	40.888 kg SO2 eq./ha	**Productivity organic**	1'520 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 20 (Abeliotis et al. 2013) Remark:

Crop	Bean (variety Plake)	**Relative difference per product unit (basis = conv)**	54%	**Relative difference productivity (basis = conv)**	32%
Landscape	Lowland / hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 1996
Impact category	Eutrophication	**Relative difference per area and year (basis = conv)**	104%	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.0027 kg PO43- eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.00417 kg PO43- eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	3.105 kg PO43- eq./ha	**Productivity conventional**	1'150 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	6.3384 kg PO43- eq./ha	**Productivity organic**	1'520 kg/ha	**Uncertainty analysis on results**	no

Bos 2007 Netherlands

Data source: Model farms for different farm types, data origin not further specified

Arable Crops Sample 21 (Bos 2007) Remark:

Crop	Potato	**Relative difference per product unit (basis = conv)**	15%	**Relative difference productivity (basis = conv)**	?
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	?
Impact category	GWP	**Relative difference per area and year (basis = conv)**	?	**Impact assessment method**	?
Impact per product unit conventional	0.203 kg CO2 eq. / kg (DM)	**Significant difference (area and year)?**	-	**Site specific emission- and characterization factors used**	?
Impact per product unit organic	0.234 kg CO2 eq. / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	?
Impact per area and year conventional	? -	**Productivity conventional**	? ?	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	? -	**Productivity organic**	? ?	**Uncertainty analysis on results**	no

Arable Crops Sample 22 (Bos 2007) Remark:

Crop	Sugar beet	**Relative difference per product unit (basis = conv)**	-41%	**Relative difference productivity (basis = conv)**	?
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	?
Impact category	GWP	**Relative difference per area and year (basis = conv)**	?	**Impact assessment method**	?
Impact per product unit conventional	0.075 kg CO2 eq. / kg (DM)	**Significant difference (area and year)?**	-	**Site specific emission- and characterization factors used**	?
Impact per product unit organic	0.044 kg CO2 eq. / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	?
Impact per area and year conventional	? -	**Productivity conventional**	? ?	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	? -	**Productivity organic**	? ?	**Uncertainty analysis on results**	no

Grönroos et al. 2006 Finnland

Data source: primary data assessed on 1 organic and 1 conventional farm

Arable Crops Sample 23 (Grönroos et al. 2006) Remark:

Crop	Rey	**Relative difference per product unit (basis = conv)**	-56%	**Relative difference productivity (basis = conv)**	-27%
Landscape	?	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	-
Impact category	energy demand	**Relative difference per area and year (basis = conv)**	-68%	**Impact assessment method**	Cumulative energy demand
Impact per product unit conventional	3.65 MJ/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	-
Impact per product unit organic	1.61 MJ/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	10'950 MJ/ha * y-1	**Productivity conventional**	3'000 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	3'542 MJ/ha * y-1	**Productivity organic**	2'200 kg/ha	**Uncertainty analysis on results**	no

Knudsen 2010 China

Data source: primary data assessed on 20 organic and 15 conventional farms

Arable Crops Sample 24 (Knudsen 2010) Remark:

Crop	Soybean	**Relative difference per product unit (basis = conv)**	13%	**Relative difference productivity (basis = conv)**	-10%
Landscape	?	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 2006
Impact category	Land use	**Relative difference per area and year (basis = conv)**	-	**Impact assessment method**	EDIP
Impact per product unit conventional	0.32 ha / t	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.36 ha / t	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	- -	**Productivity conventional**	3'083 kg/ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	- -	**Productivity organic**	2'788 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 25 (Knudsen 2010) Remark:

Crop	Soybean	**Relative difference per product unit (basis = conv)**	-55%	**Relative difference productivity (basis = conv)**	-10%
Landscape	?	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 2006
Impact category	energy demand	**Relative difference per area and year (basis = conv)**	-59%	**Impact assessment method**	IMPACT 2002
Impact per product unit conventional	1710 MJ / t	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	773 MJ / t	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	5'272 MJ/ha * y-1	**Productivity conventional**	3'083 kg/ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	2'155 MJ/ha * y-1	**Productivity organic**	2'788 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 26 (Knudsen 2010) Remark:

Crop	Soybean	**Relative difference per product unit (basis = conv)**	-41%	**Relative difference productivity (basis = conv)**	-10%
Landscape	?	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 2006
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-46%	**Impact assessment method**	IPCC
Impact per product unit conventional	263 kg CO2 eq. / t	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	156 kg CO2 eq. / t	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	811 kg CO2 eq./ha * y-1	**Productivity conventional**	3'083 kg/ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	435 kg CO2 eq./ha * y-1	**Productivity organic**	2'788 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 27 (Knudsen 2010) Remark:

Crop	Soybean	**Relative difference per product unit (basis = conv)**	-49%	**Relative difference productivity (basis = conv)**	-10%
Landscape	?	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 2006
Impact category	Acidification	**Relative difference per area and year (basis = conv)**	-54%	**Impact assessment method**	EDIP
Impact per product unit conventional	4.5 kg SO2 eq. / t	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	2.3 kg SO2 eq. / t	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	14 kg SO2 eq./ha * y-1	**Productivity conventional**	3'083 kg/ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	6 kg SO2 eq./ha * y-1	**Productivity organic**	2'788 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 28 (Knudsen 2010) Remark:

Crop	Soybean	**Relative difference per product unit (basis = conv)**	-62%	**Relative difference productivity (basis = conv)**	-10%
Landscape	?	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 2006
Impact category	Eutrophication	**Relative difference per area and year (basis = conv)**	-65%	**Impact assessment method**	EDIP
Impact per product unit conventional	13 kg NO3 eq. / t	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	5 kg NO3 eq. / t	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	40 kg NO3 eq./ha * y-1	**Productivity conventional**	3'083 kg/ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	14 kg NO3 eq./ha * y-1	**Productivity organic**	2'788 kg/ha	**Uncertainty analysis on results**	no

Meisterling et al. 2009 USA

Data source: farm statistical data / literature data

Arable Crops Sample 29 (Meisterling et al. 2009) Remark:

Crop	Wheat	**Relative difference per product unit (basis = conv)**	-44%	**Relative difference productivity (basis = conv)**	-25%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	1.3% of total N supply
Impact category	Energy demand	**Relative difference per area and year (basis = conv)**	-58%	**Impact assessment method**	IPCC 2006
Impact per product unit conventional	2.09 MJ/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	1.18 MJ/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	5851 MJ/ha * y-1	**Productivity conventional**	2'800 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	2476 MJ/ha * y-1	**Productivity organic**	2'100 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 30 (Meisterling et al. 2009) Remark:

Crop	Wheat	**Relative difference per product unit (basis = conv)**	-16%	**Relative difference productivity (basis = conv)**	-25%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	1.3% of total N supply
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-37%	**Impact assessment method**	Cumulative energy demand
Impact per product unit conventional	0.28 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.24 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	794 kg CO2 eq./ha * y-1	**Productivity conventional**	2'800 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	501 kg CO2 eq./ha * y-1	**Productivity organic**	2'100 kg/ha	**Uncertainty analysis on results**	no

Nemecek et al. 2010 CH

Data source: primary data from long term field trials

Arable Crops Sample 31 (Nemecek et al. 2010) Remark: variant D1 compared to C2

Crop	Crop rotation: DOC	**Relative difference per product unit (basis = conv)**	30%	**Relative difference productivity (basis = conv)**	-22%
Landscape	lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	land use	**Relative difference per area and year (basis = conv)**	-	**Impact assessment method**	LCI
Impact per product unit conventional	0.99 m2 * y / kg (DM)	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	1.29 m2 * y / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	- -	**Productivity conventional**	10'209 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	- -	**Productivity organic**	7'920 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 32 (Nemecek et al. 2010) Remark: variant D1 compared to C2

Crop	Crop rotation: DOC	**Relative difference per product unit (basis = conv)**	-10%	**Relative difference productivity (basis = conv)**	-22%
Landscape	lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	energy demand	**Relative difference per area and year (basis = conv)**	-31%	**Impact assessment method**	CED
Impact per product unit conventional	2.0 MJ/kg (DM)	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	1.8 MJ/kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	21.0 GJ/ha * y-1	**Productivity conventional**	10'209 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	14.5 GJ/ha * y-1	**Productivity organic**	7'920 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 33 (Nemecek et al. 2010) Remark: variant D1 compared to C2

Crop	Crop rotation: DOC	**Relative difference per product unit (basis = conv)**	-16%	**Relative difference productivity (basis = conv)**	-22%
Landscape	lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-35%	**Impact assessment method**	IPCC 2001
Impact per product unit conventional	0.43 kg CO2 eq. / kg (DM)	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	for N2O
Impact per product unit organic	0.36 kg CO2 eq. / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	4474 kg CO2 eq. /ha * y-1	**Productivity conventional**	10'209 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	2920 kg CO2 eq. /ha * y-1	**Productivity organic**	7'920 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 34 (Nemecek et al. 2010) Remark: variant D1 compared to C2

Crop	Crop rotation: DOC	**Relative difference per product unit (basis = conv)**	9%	**Relative difference productivity (basis = conv)**	-22%
Landscape	lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	Photochemical oxidation	**Relative difference per area and year (basis = conv)**	-16%	**Impact assessment method**	EDIP97
Impact per product unit conventional	93 mg C2H4 eq. / kg (DM)	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	101 mg C2H4 eq. / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	0.99 kg C2H4 eq. / ha * y-1	**Productivity conventional**	10'209 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	0.83 kg C2H4 eq. / ha * y-1	**Productivity organic**	7'920 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 35 (Nemecek et al. 2010) Remark: variant D1 compared to C2

Crop	Crop rotation: DOC	**Relative difference per product unit (basis = conv)**	-96%	**Relative difference productivity (basis = conv)**	-22%
Landscape	lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	resource use P	**Relative difference per area and year (basis = conv)**	-97%	**Impact assessment method**	LCI
Impact per product unit conventional	1.07 g P / kg (DM)	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.04 g P / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	11.3 kg P /ha * y-1	**Productivity conventional**	10'209 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	0.3 kg P /ha * y-1	**Productivity organic**	7'920 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 36 (Nemecek et al. 2010) Remark: variant D1 compared to C2

Crop	Crop rotation: DOC	**Relative difference per product unit (basis = conv)**	-66%	**Relative difference productivity (basis = conv)**	-22%
Landscape	lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	resource use K	**Relative difference per area and year (basis = conv)**	-75%	**Impact assessment method**	LCA
Impact per product unit conventional	13 g K / kg (DM)	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	4.4 g K / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	138 kg K /ha * y-1	**Productivity conventional**	10'209 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	34 kg K /ha * y-1	**Productivity organic**	7'920 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 37 (Nemecek et al. 2010) Remark: variant D1 compared to C2

Crop	Crop rotation: DOC	**Relative difference per product unit (basis = conv)**	-9%	**Relative difference productivity (basis = conv)**	-22%
Landscape	lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	eutrophication	**Relative difference per area and year (basis = conv)**	-28%	**Impact assessment method**	EDIP97
Impact per product unit conventional	11.9 g N-eq./kg (DM)	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	10.8 g N-eq./kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	123 kg N-equ./ha * y-1	**Productivity conventional**	10'209 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	88 kg N-equ./ha * y-1	**Productivity organic**	7'920 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 38 (Nemecek et al. 2010) Remark: variant D1 compared to C2

Crop	Crop rotation: DOC	**Relative difference per product unit (basis = conv)**	-11%	**Relative difference productivity (basis = conv)**	-22%
Landscape	lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	Acidification	**Relative difference per area and year (basis = conv)**	-31%	**Impact assessment method**	EDIP97
Impact per product unit conventional	8.66 g SO2-eq./kg (DM)	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	7.72 g SO2-eq./kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	88 kg SO2-equ./ha * y-1	**Productivity conventional**	10'209 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	61 kg SO2-equ./ha * y-1	**Productivity organic**	7'920 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 39 (Nemecek et al. 2010) Remark: variant D1 compared to C2

Crop	Crop rotation: DOC	**Relative difference per product unit (basis = conv)**	-84%	**Relative difference productivity (basis = conv)**	-22%
Landscape	lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	ecotox aquatic	**Relative difference per area and year (basis = conv)**	-87%	**Impact assessment method**	EDIP97
Impact per product unit conventional	0.63 AEP / kg (DM)	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.1 AEP / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	6477 AEP /ha * y-1	**Productivity conventional**	10'209 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	816 AEP /ha * y-1	**Productivity organic**	7'920 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 40 (Nemecek et al. 2010) Remark: variant D1 compared to C2

Crop	Crop rotation: DOC	**Relative difference per product unit (basis = conv)**	-98%	**Relative difference productivity (basis = conv)**	-22%
Landscape	lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	ecotox terrestrial	**Relative difference per area and year (basis = conv)**	-99%	**Impact assessment method**	EDIP97
Impact per product unit conventional	0.57 TEP/kg DM	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.01 TEP/kg DM	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	6187 TEP/ha * y-1	**Productivity conventional**	10'209 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	60 TEP/ha * y-1	**Productivity organic**	7'920 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 41 (Nemecek et al. 2010) Remark: variant D1 compared to C2

Crop	Crop rotation: DOC	**Relative difference per product unit (basis = conv)**	-50%	**Relative difference productivity (basis = conv)**	-22%
Landscape	lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	human tox	**Relative difference per area and year (basis = conv)**	-65%	**Impact assessment method**	CML01
Impact per product unit conventional	0.12 HTP / kg (DM)	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.06 HTP / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	1286 HTP /ha * y-1	**Productivity conventional**	10'209 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	446 HTP /ha * y-1	**Productivity organic**	7'920 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 42 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	13%	**Relative difference productivity (basis = conv)**	-12%
Landscape	lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	land use	**Relative difference per area and year (basis = conv)**	-	**Impact assessment method**	LCI
Impact per product unit conventional	0.83 m2 * y / kg (DM)	**Significant difference (area and year)?**	-	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.94 m2 * y / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	- -	**Productivity conventional**	12'103 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	- -	**Productivity organic**	10'627 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 43 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	-15%	**Relative difference productivity (basis = conv)**	-12%
Landscape	lowland	**Significant difference (product unit)?**	P < 0.05	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	energy demand	**Relative difference per area and year (basis = conv)**	-27%	**Impact assessment method**	CED
Impact per product unit conventional	1.74 MJ/kg (DM)	**Significant difference (area and year)?**	P < 0.05	**Site specific emission- and characterization factors used**	
Impact per product unit organic	1.48 MJ/kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	22 GJ/ha * y-1	**Productivity conventional**	12'103 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	16 GJ/ha * y-1	**Productivity organic**	10'627 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 44 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	-18%	**Relative difference productivity (basis = conv)**	-12%
Landscape	lowland	**Significant difference (product unit)?**	P < 0.05	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-28%	**Impact assessment method**	IPCC 2001
Impact per product unit conventional	409 kg CO2 eq. / kg (DM)	**Significant difference (area and year)?**	P < 0.05	**Site specific emission- and characterization factors used**	for N2O
Impact per product unit organic	335 kg CO2 eq. / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	5026 kg CO2 eq. /ha * y-1	**Productivity conventional**	12'103 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	3604 kg CO2 eq. /ha * y-1	**Productivity organic**	10'627 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 45 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	-1%	**Relative difference productivity (basis = conv)**	-12%
Landscape	lowland	**Significant difference (product unit)?**	n.s.	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	Photochemical oxidation	**Relative difference per area and year (basis = conv)**	-13%	**Impact assessment method**	EDIP97
Impact per product unit conventional	80 mg C2H4 eq. / kg (DM)	**Significant difference (area and year)?**	P < 0.05	**Site specific emission- and characterization factors used**	
Impact per product unit organic	79 mg C2H4 eq. / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	1 kg C2H4 eq. / ha * y-1	**Productivity conventional**	12'103 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	0.87 kg C2H4 eq. / ha * y-1	**Productivity organic**	10'627 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 46 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	-3%	**Relative difference productivity (basis = conv)**	-12%
Landscape	lowland	**Significant difference (product unit)?**	n.s.	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	eutrophication	**Relative difference per area and year (basis = conv)**	-14%	**Impact assessment method**	EDIP97
Impact per product unit conventional	11.7 g N-equ./kg (DM)	**Significant difference (area and year)?**	P < 0.05	**Site specific emission- and characterization factors used**	
Impact per product unit organic	11.4 g N-equ./kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	143 kg N-equ./ha * y-1	**Productivity conventional**	12'103 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	123 kg N-equ./ha * y-1	**Productivity organic**	10'627 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 47 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	7%	**Relative difference productivity (basis = conv)**	-12%
Landscape	lowland	**Significant difference (product unit)?**	n.s.	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	Acidification	**Relative difference per area and year (basis = conv)**	-4%	**Impact assessment method**	EDIP97
Impact per product unit conventional	8 g SO2-eq./kg (DM)	**Significant difference (area and year)?**	n.s.	**Site specific emission- and characterization factors used**	
Impact per product unit organic	8.6 g SO2-eq./kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	97 kg SO2-equ./ha * y-1	**Productivity conventional**	12'103 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	93 kg SO2-equ./ha * y-1	**Productivity organic**	10'627 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 48 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	-25%	**Relative difference productivity (basis = conv)**	-12%
Landscape	lowland	**Significant difference (product unit)?**	P < 0.05	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	ecotox aquatic	**Relative difference per area and year (basis = conv)**	-40%	**Impact assessment method**	EDIP97
Impact per product unit conventional	0.08 AEP / kg (DM)	**Significant difference (area and year)?**	P < 0.05	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.06 AEP / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	1012 AEP /ha * y-1	**Productivity conventional**	12'103 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	603 AEP /ha * y-1	**Productivity organic**	10'627 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 49 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	-100%	**Relative difference productivity (basis = conv)**	-12%
Landscape	lowland	**Significant difference (product unit)?**	P < 0.05	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	ecotox terrestrial	**Relative difference per area and year (basis = conv)**	-98%	**Impact assessment method**	EDIP97
Impact per product unit conventional	0.27 TEP/kg DM	**Significant difference (area and year)?**	P < 0.05	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0 TEP/kg DM	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	3233 TEP/ha * y-1	**Productivity conventional**	12'103 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	51 TEP/ha * y-1	**Productivity organic**	10'627 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 50 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	-20%	**Relative difference productivity (basis = conv)**	-12%
Landscape	lowland	**Significant difference (product unit)?**	P < 0.05	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	human tox	**Relative difference per area and year (basis = conv)**	-34%	**Impact assessment method**	CML01
Impact per product unit conventional	0.05 HTP / kg (DM)	**Significant difference (area and year)?**	P < 0.05	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.04 HTP / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	631 HTP /ha * y-1	**Productivity conventional**	12'103 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	414 HTP /ha * y-1	**Productivity organic**	10'627 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 51 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	9%	**Relative difference productivity (basis = conv)**	-9%
Landscape	lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	land use	**Relative difference per area and year (basis = conv)**	-	**Impact assessment method**	LCI
Impact per product unit conventional	0.77 m2 * y / kg (DM)	**Significant difference (area and year)?**	-	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.84 m2 * y / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	- -	**Productivity conventional**	13'025 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	- -	**Productivity organic**	11'914 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 52 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	-19%	**Relative difference productivity (basis = conv)**	-9%
Landscape	lowland	**Significant difference (product unit)?**	$P < 0.05$	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	energy demand	**Relative difference per area and year (basis = conv)**	-23%	**Impact assessment method**	CED
Impact per product unit conventional	0.96 MJ/kg (DM)	**Significant difference (area and year)?**	$P < 0.05$	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.78 MJ/kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	13 GJ/ha * y-1	**Productivity conventional**	13'025 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	10 GJ/ha * y-1	**Productivity organic**	11'914 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 53 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	-24%	**Relative difference productivity (basis = conv)**	-9%
Landscape	lowland	**Significant difference (product unit)?**	$P < 0.05$	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-30%	**Impact assessment method**	IPCC 2001
Impact per product unit conventional	284 kg CO2 eq. / kg (DM)	**Significant difference (area and year)?**	$P < 0.05$	**Site specific emission- and characterization factors used**	for N2O
Impact per product unit organic	217 kg CO2 eq. / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	3773 kg CO2 eq. /ha * y-1	**Productivity conventional**	13'025 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	2633 kg CO2 eq. /ha * y-1	**Productivity organic**	11'914 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 54 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	-9%	**Relative difference productivity (basis = conv)**	-9%
Landscape	lowland	**Significant difference (product unit)?**	$P < 0.05$	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	Photochemical oxidation	**Relative difference per area and year (basis = conv)**	-17%	**Impact assessment method**	EDIP97
Impact per product unit conventional	56 mg C2H4 eq. / kg (DM)	**Significant difference (area and year)?**	$P < 0.05$	**Site specific emission- and characterization factors used**	
Impact per product unit organic	51 mg C2H4 eq. / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	0.76 kg C2H4 eq. / ha * y-1	**Productivity conventional**	13'025 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	0.63 kg C2H4 eq. / ha * y-1	**Productivity organic**	11'914 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 55 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	-16%	**Relative difference productivity (basis = conv)**	-9%
Landscape	lowland	**Significant difference (product unit)?**	$P < 0.05$	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	eutrophication	**Relative difference per area and year (basis = conv)**	-23%	**Impact assessment method**	EDIP97
Impact per product unit conventional	10.1 g N-equ./kg (DM)	**Significant difference (area and year)?**	$P < 0.05$	**Site specific emission- and characterization factors used**	
Impact per product unit organic	8.5 g N-equ./kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	134 kg N-equ./ha * y-1	**Productivity conventional**	13'025 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	103 kg N-equ./ha * y-1	**Productivity organic**	11'914 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 56 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	-9%	**Relative difference productivity (basis = conv)**	-9%
Landscape	lowland	**Significant difference (product unit)?**	n.s.	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	Acidification	**Relative difference per area and year (basis = conv)**	-16%	**Impact assessment method**	EDIP97
Impact per product unit conventional	7.4 g SO2-eq./kg (DM)	**Significant difference (area and year)?**	$P < 0.05$	**Site specific emission- and characterization factors used**	
Impact per product unit organic	6.7 g SO2-eq./kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	97 kg SO2-equ./ha * y-1	**Productivity conventional**	13'025 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	81 kg SO2-equ./ha * y-1	**Productivity organic**	11'914 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 57 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	-40%	**Relative difference productivity (basis = conv)**	-9%
Landscape	lowland	**Significant difference (product unit)?**	n.s.	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	ecotox aquatic	**Relative difference per area and year (basis = conv)**	-36%	**Impact assessment method**	EDIP97
Impact per product unit conventional	0.05 AEP / kg (DM)	**Significant difference (area and year)?**	n.s.	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.03 AEP / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	624 AEP /ha * y-1	**Productivity conventional**	13'025 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	400 AEP /ha * y-1	**Productivity organic**	11'914 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 58 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	-100%	**Relative difference productivity (basis = conv)**	-9%
Landscape	lowland	**Significant difference (product unit)?**	n.s.	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	ecotox terrestrial	**Relative difference per area and year (basis = conv)**	-95%	**Impact assessment method**	EDIP97
Impact per product unit conventional	0.05 TEP/kg DM	**Significant difference (area and year)?**	n.s.	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0 TEP/kg DM	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	699 TEP/ha * y-1	**Productivity conventional**	13'025 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	37 TEP/ha * y-1	**Productivity organic**	11'914 kg (DM) / ha	**Uncertainty analysis on results**	no

Arable Crops Sample 59 (Nemecek et al. 2010) Remark:

Crop	Crop rotation: Burgrain Cash-CR	**Relative difference per product unit (basis = conv)**	-33%	**Relative difference productivity (basis = conv)**	-9%
Landscape	lowland	**Significant difference (product unit)?**	P < 0.05	**Calculation basis for N2O-emissions soils**	Schmid et al. (2000)
Impact category	human tox	**Relative difference per area and year (basis = conv)**	-35%	**Impact assessment method**	CML01
Impact per product unit conventional	0.03 HTP / kg (DM)	**Significant difference (area and year)?**	P < 0.05	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.02 HTP / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	428 HTP /ha * y-1	**Productivity conventional**	13'025 kg (DM) / ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	280 HTP /ha * y-1	**Productivity organic**	11'914 kg (DM) / ha	**Uncertainty analysis on results**	no

Venkat 2012 USA (California)

Data source: literature data (cost and return studies)

Arable Crops Sample 60 (Venkat 2012) Remark:

Crop	Alfalfa	**Relative difference per product unit (basis = conv)**	-35%	**Relative difference productivity (basis = conv)**	17%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	IPCC 2005
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-24%	**Impact assessment method**	GWP109
Impact per product unit conventional	0.132 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.086 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	1775 kg CO2 eq./ha	**Productivity conventional**	13'450 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	1350 kg CO2 eq./ha	**Productivity organic**	15'692 kg/ha	**Uncertainty analysis on results**	no

Williams et al. 2006 UK

Data source: farm statistical data / database data / literature data / expert judgement

Arable Crops Sample 61 (Williams et al. 2006) Remark:

Crop	Potato	**Relative difference per product unit (basis = conv)**	164%	**Relative difference productivity (basis = conv)**	-62%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	land use	**Relative difference per area and year (basis = conv)**	-	**Impact assessment method**	LCI
Impact per product unit conventional	2.2e-005 ha/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	5.8e-005 ha/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	- -	**Productivity conventional**	45'455 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	- -	**Productivity organic**	17'241 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 62 (Williams et al. 2007) Remark:

Crop	Potato	**Relative difference per product unit (basis = conv)**	2%	**Relative difference productivity (basis = conv)**	-62%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	energy demand	**Relative difference per area and year (basis = conv)**	-61%	**Impact assessment method**	Cumulative energy demand
Impact per product unit conventional	1.26 MJ/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	1.28 MJ/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	57'273 MJ/ha * y-1	**Productivity conventional**	45'455 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	22'068 MJ/ha * y-1	**Productivity organic**	17'241 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 63 (Williams et al. 2006) Remark:

Crop	Potato	**Relative difference per product unit (basis = conv)**	-7%	**Relative difference productivity (basis = conv)**	-62%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-65%	**Impact assessment method**	GWP100 (emission factors: CO2 = 1, CH4 = 23, N2O = 296)
Impact per product unit conventional	0.215 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.199 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	9'773 kg CO2 equ./ha * y-1	**Productivity conventional**	45'455 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	3'431 kg CO2 equ./ha * y-1	**Productivity organic**	17'241 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 64 (Williams et al. 2006) Remark:

Crop	Potato	**Relative difference per product unit (basis = conv)**	9%	**Relative difference productivity (basis = conv)**	-62%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	eutrophication	**Relative difference per area and year (basis = conv)**	-59%	**Impact assessment method**	based on NO3, PO4 and NH3 emissions quantified in terms of phosphate equivalents (1 kg NO3-N = 0.44 kg PO4, 1 kg NH3-N = 0.43 kg PO4)
Impact per product unit conventional	0.0011 kg PO43- eq/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.0012 kg PO43- eq/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	50 kg PO43- equ./ha * y-1	**Productivity conventional**	45'455 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	21 kg PO43- equ./ha * y-1	**Productivity organic**	17'241 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 65 (Williams et al. 2006) Remark:

Crop	Potato	**Relative difference per product unit (basis = conv)**	-58%	**Relative difference productivity (basis = conv)**	-62%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	Acidification	**Relative difference per area and year (basis = conv)**	-84%	**Impact assessment method**	based on SO2 and NH3 emissions quantified in terms of SO2 equivalents (1 kg NH3-N = 2.3 kg SO2)
Impact per product unit conventional	0.0019 kg SO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.0008 kg SO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	86 SO2 equ./ha * y-1	**Productivity conventional**	45'455 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	14 SO2 equ./ha * y-1	**Productivity organic**	17'241 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 66 (Williams et al. 2007) Remark:

Crop	Potato	**Relative difference per product unit (basis = conv)**	-80%	**Relative difference productivity (basis = conv)**	-62%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	Pesticide use	**Relative difference per area and year (basis = conv)**	-92%	**Impact assessment method**	LCI
Impact per product unit conventional	0.0005 dose ha/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.0001 dose ha/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	23 dose/ha * y-1	**Productivity conventional**	45'455 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	2 dose/ha * y-1	**Productivity organic**	17'241 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 67 (Williams et al. 2008) Remark:

Crop	Potato	**Relative difference per product unit (basis = conv)**	22%	**Relative difference productivity (basis = conv)**	-62%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	abiotic resource use	**Relative difference per area and year (basis = conv)**	-54%	**Impact assessment method**	CML
Impact per product unit conventional	0.0009 kg antimony eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.0011 kg antimony eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	41 kg antimony equ./ha * y-1	**Productivity conventional**	45'455 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	19 kg antimony equ./ha * y-1	**Productivity organic**	17'241 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 68 (Williams et al. 2006) Remark: includes crop cooling, storage and drying

Crop	Wheat	**Relative difference per product unit (basis = conv)**	214%	**Relative difference productivity (basis = conv)**	-68%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	land use	**Relative difference per area and year (basis = conv)**	-	**Impact assessment method**	LCI
Impact per product unit conventional	0.00014 ha/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.00044 ha/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	- -	**Productivity conventional**	7'143 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	- -	**Productivity organic**	2'273 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 69 (Williams et al. 2006) Remark: includes crop cooling, storage and drying

Crop	Wheat	**Relative difference per product unit (basis = conv)**	-29%	**Relative difference productivity (basis = conv)**	-68%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	energy demand	**Relative difference per area and year (basis = conv)**	-77%	**Impact assessment method**	Cumulative energy demand
Impact per product unit conventional	2.46 MJ / kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	1.74 MJ / kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	17'572 MJ / ha * y-1	**Productivity conventional**	7'143 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	3'955 MJ / ha * y-1	**Productivity organic**	2'273 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 70 (Williams et al. 2006) Remark: includes crop cooling, storage and drying

Crop	Wheat	**Relative difference per product unit (basis = conv)**	-2%	**Relative difference productivity (basis = conv)**	-68%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-69%	**Impact assessment method**	GWP100 (emission factors: CO2 = 1, CH4 = 23, N2O = 296)
Impact per product unit conventional	0.804 kg CO2 equ./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.786 kg CO2 equ./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	5'743 kg CO2 equ./ha * y-1	**Productivity conventional**	7'143 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	1'787 kg CO2 equ./ha * y-1	**Productivity organic**	2'273 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 71 (Williams et al. 2006) Remark: includes crop cooling, storage and drying

Crop	Wheat	**Relative difference per product unit (basis = conv)**	200%	**Relative difference productivity (basis = conv)**	-68%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	eutrophication	**Relative difference per area and year (basis = conv)**	-5%	**Impact assessment method**	based on NO3, PO4 and NH3 emissions quantified in terms of phosphate equivalents (1 kg NO3-N = 0.44 kg PO4, 1 kg NH3-N = 0.43 kg PO4)
Impact per product unit conventional	0.0031 kg PO43- equ./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.0093 kg PO43- equ./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	22 kg PO43- equ./ha * y-1	**Productivity conventional**	7'143 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	21 kg PO43- equ./ha * y-1	**Productivity organic**	2'273 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 72 (Williams et al. 2006) Remark: includes crop cooling, storage and drying

Crop	Wheat	**Relative difference per product unit (basis = conv)**	6%	**Relative difference productivity (basis = conv)**	-68%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	Acidification	**Relative difference per area and year (basis = conv)**	-66%	**Impact assessment method**	based on SO2 and NH3 emissions quantified in terms of SO2 equivalents (1 kg NH3-N = 2.3 kg SO2)
Impact per product unit conventional	0.0032 SO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.0034 SO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	23 SO2 equ./ha * y-1	**Productivity conventional**	7'143 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	8 SO2 equ./ha * y-1	**Productivity organic**	2'273 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 73 (Williams et al. 2006) Remark: includes crop cooling, storage and drying

Crop	Wheat	**Relative difference per product unit (basis = conv)**	-100%	**Relative difference productivity (basis = conv)**	-68%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	Pesticide use	**Relative difference per area and year (basis = conv)**	-100%	**Impact assessment method**	LCI
Impact per product unit conventional	0.002 dose/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0 dose/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	14 dose/ha * y-1	**Productivity conventional**	7'143 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0 dose/ha * y-1	**Productivity organic**	2'273 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 74 (Williams et al. 2006) Remark: includes crop cooling, storage and drying

Crop	Wheat	**Relative difference per product unit (basis = conv)**	-13%	**Relative difference productivity (basis = conv)**	-68%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	abiotic resource use	**Relative difference per area and year (basis = conv)**	-72%	**Impact assessment method**	CML
Impact per product unit conventional	0.0015 kg antimony eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.0013 kg antimony eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	11 kg antimony equ./ha * y-1	**Productivity conventional**	7'143 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	3 kg antimony equ./ha * y-1	**Productivity organic**	2'273 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 75 (Williams et al. 2006) Remark:

Crop	Oilseed rape	**Relative difference per product unit (basis = conv)**	173%	**Relative difference productivity (basis = conv)**	-63%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	land use	**Relative difference per area and year (basis = conv)**	-	**Impact assessment method**	LCI
Impact per product unit conventional	0.000309 ha/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.000845 ha/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	- -	**Productivity conventional**	3'236 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	- -	**Productivity organic**	1'183 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 76 (Williams et al. 2006) Remark:

Crop	Oilseed rape	**Relative difference per product unit (basis = conv)**	-25%	**Relative difference productivity (basis = conv)**	-63%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	energy demand	**Relative difference per area and year (basis = conv)**	-73%	**Impact assessment method**	Cumulative energy demand
Impact per product unit conventional	5.39 MJ / kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	4.02 MJ / kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	17442 MJ / ha * y-1	**Productivity conventional**	3'236 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	4756 MJ / ha * y-1	**Productivity organic**	1'183 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 77 (Williams et al. 2006) Remark:

Crop	Oilseed rape	**Relative difference per product unit (basis = conv)**	-5%	**Relative difference productivity (basis = conv)**	-63%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-65%	**Impact assessment method**	GWP100 (emission factors: CO2 = 1, CH4 = 23, N2O = 296)
Impact per product unit conventional	1.71 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	1.62 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	5534 kg CO2 equ./ha * y-1	**Productivity conventional**	3'236 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	1916 kg CO2 equ./ha * y-1	**Productivity organic**	1'183 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 78 (Williams et al. 2006) Remark:

Crop	Oilseed rape	**Relative difference per product unit (basis = conv)**	76%	**Relative difference productivity (basis = conv)**	-63%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	eutrophication	**Relative difference per area and year (basis = conv)**	-36%	**Impact assessment method**	based on NO3, PO4 and NH3 emissions quantified in terms of phosphate equivalents (1 kg NO3-N = 0.44 kg PO4, 1 kg NH3-N = 0.43 kg PO4)
Impact per product unit conventional	0.0084 kg PO43- eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.0148 kg PO43- eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	27 kg PO43- equ./ha * y-1	**Productivity conventional**	3'236 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	18 kg PO43- equ./ha * y-1	**Productivity organic**	1'183 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 79 (Williams et al. 2006) Remark:

Crop	Oilseed rape	**Relative difference per product unit (basis = conv)**	-38%	**Relative difference productivity (basis = conv)**	-63%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	Acidification	**Relative difference per area and year (basis = conv)**	-77%	**Impact assessment method**	based on SO2 and NH3 emissions quantified in terms of SO2 equivalents (1 kg NH3-N = 2.3 kg SO2)
Impact per product unit conventional	0.0092 SO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.0057 SO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	30 SO2 equ./ha * y-1	**Productivity conventional**	3'236 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	7 SO2 equ./ha * y-1	**Productivity organic**	1'183 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 80 (Williams et al. 2006) Remark:

Crop	Oilseed rape	**Relative difference per product unit (basis = conv)**	-100%	**Relative difference productivity (basis = conv)**	-63%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	Pesticide use	**Relative difference per area and year (basis = conv)**	-100%	**Impact assessment method**	LCI
Impact per product unit conventional	0.0045 dose/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0 dose/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	15 dose/ha * y-1	**Productivity conventional**	3'236 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0 dose/ha * y-1	**Productivity organic**	1'183 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 81 (Williams et al. 2006) Remark:

Crop	Oilseed rape	**Relative difference per product unit (basis = conv)**	-12%	**Relative difference productivity (basis = conv)**	-63%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	Calculated following the methods of the national inventories for methane, ammonia, and nitrous oxide
Impact category	abiotic resource use	**Relative difference per area and year (basis = conv)**	-68%	**Impact assessment method**	CML
Impact per product unit conventional	0.0033 kg antimony eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.0029 kg antimony eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	11 kg antimony equ./ha * y-1	**Productivity conventional**	3'236 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	3 kg antimony equ./ha * y-1	**Productivity organic**	1'183 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 82 (Williams et al. 2010) Remark:

Crop	Wheat	**Relative difference per product unit (basis = conv)**	-17%	**Relative difference productivity (basis = conv)**	-47%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	SUNDIAL simulation program (Smith et al., 1996)
Impact category	Energy demand	**Relative difference per area and year (basis = conv)**	-56%	**Impact assessment method**	?
Impact per product unit conventional	2.4 MJ/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	2.0 MJ/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	18480 MJ/ha * y-1	**Productivity conventional**	7'700 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	8200 MJ/ha * y-1	**Productivity organic**	4'100 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 83 (Williams et al. 2010) Remark:

Crop	Wheat	**Relative difference per product unit (basis = conv)**	14%	**Relative difference productivity (basis = conv)**	-47%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	SUNDIAL simulation program (Smith et al., 1996)
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-39%	**Impact assessment method**	IPCC 2001
Impact per product unit conventional	0.7 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.8 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	5390 kg CO2 eq./ha * y-1	**Productivity conventional**	7'700 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	3280 kg CO2 eq./ha * y-1	**Productivity organic**	4'100 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 84 (Williams et al. 2010) Remark:

Crop	Wheat	**Relative difference per product unit (basis = conv)**	210%	**Relative difference productivity (basis = conv)**	-47%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	SUNDIAL simulation program (Smith et al., 1996)
Impact category	Eutrophication	**Relative difference per area and year (basis = conv)**	65%	**Impact assessment method**	CML 1999
Impact per product unit conventional	0.003 kg PO43- eq/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.0093 kg PO43- eq/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	23.1 kg PO43- eq/ha * y-1	**Productivity conventional**	7'700 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	38.13 kg PO43- eq/ha * y-1	**Productivity organic**	4'100 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 85 (Williams et al. 2010) Remark:

Crop	Wheat	**Relative difference per product unit (basis = conv)**	9%	**Relative difference productivity (basis = conv)**	-47%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	SUNDIAL simulation program (Smith et al., 1996)
Impact category	Acidification	**Relative difference per area and year (basis = conv)**	-42%	**Impact assessment method**	CML 1999
Impact per product unit conventional	0.0033 kg SO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.0036 kg SO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	25.41 kg SO2 eq./ha * y-1	**Productivity conventional**	7'700 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	14.76 kg SO2 eq./ha * y-1	**Productivity organic**	4'100 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 86 (Williams et al. 2010) Remark:

Crop	Wheat	**Relative difference per product unit (basis = conv)**	-100%	**Relative difference productivity (basis = conv)**	-47%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	SUNDIAL simulation program (Smith et al., 1996)
Impact category	Pesticide use	**Relative difference per area and year (basis = conv)**	-100%	**Impact assessment method**	?
Impact per product unit conventional	0.92 dose ha/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0 dose ha/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	7084 dose ha/ha * y-1	**Productivity conventional**	7'700 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0 dose ha/ha * y-1	**Productivity organic**	4'100 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 87 (Williams et al. 2010) Remark:

Crop	Wheat	**Relative difference per product unit (basis = conv)**	-7%	**Relative difference productivity (basis = conv)**	-47%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	SUNDIAL simulation program (Smith et al., 1996)
Impact category	Abiotic resource use	**Relative difference per area and year (basis = conv)**	-50%	**Impact assessment method**	CML 1999
Impact per product unit conventional	0.0015 kg antimony eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.0014 kg antimony eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	11.55 kg antimony eq./ha * y-1	**Productivity conventional**	7'700 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	5.74 kg antimony eq./ha * y-1	**Productivity organic**	4'100 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 88 (Williams et al. 2010) Remark:

Crop	Wheat	**Relative difference per product unit (basis = conv)**	193%	**Relative difference productivity (basis = conv)**	-47%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	SUNDIAL simulation program (Smith et al., 1996)
Impact category	Land use	**Relative difference per area and year (basis = conv)**	-	**Impact assessment method**	-
Impact per product unit conventional	0.00014 ha/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.00041 ha/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	- -	**Productivity conventional**	7'700 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	- -	**Productivity organic**	4'100 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 89 (Williams et al. 2010) Remark:

Crop	Potato	**Relative difference per product unit (basis = conv)**	14%	**Relative difference productivity (basis = conv)**	-31%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	SUNDIAL simulation program (Smith et al., 1996)
Impact category	Energy demand	**Relative difference per area and year (basis = conv)**	-21%	**Impact assessment method**	?
Impact per product unit conventional	1.4 MJ/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	1.6 MJ/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	58800 MJ/ha * y-1	**Productivity conventional**	42'000 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	46400 MJ/ha * y-1	**Productivity organic**	29'000 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 90 (Williams et al. 2010) Remark:

Crop	Potato	**Relative difference per product unit (basis = conv)**	5%	**Relative difference productivity (basis = conv)**	-31%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	SUNDIAL simulation program (Smith et al., 1996)
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-27%	**Impact assessment method**	IPCC 2001
Impact per product unit conventional	0.19 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.2 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	7980 kg CO2 eq./ha * y-1	**Productivity conventional**	42'000 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	5800 kg CO2 eq./ha * y-1	**Productivity organic**	29'000 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 91 (Williams et al. 2010) Remark:

Crop	Potato	**Relative difference per product unit (basis = conv)**	88%	**Relative difference productivity (basis = conv)**	-31%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	SUNDIAL simulation program (Smith et al., 1996)
Impact category	Eutrophication	**Relative difference per area and year (basis = conv)**	29%	**Impact assessment method**	CML 1999
Impact per product unit conventional	0.0008 kg PO43- eq/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.0015 kg PO43- eq/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	33.6 kg PO43- eq/ha * y-1	**Productivity conventional**	42'000 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	43.5 kg PO43- eq/ha * y-1	**Productivity organic**	29'000 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 92 (Williams et al. 2010) Remark:

Crop	Potato	**Relative difference per product unit (basis = conv)**	23%	**Relative difference productivity (basis = conv)**	-31%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	SUNDIAL simulation program (Smith et al., 1996)
Impact category	Acidification	**Relative difference per area and year (basis = conv)**	-15%	**Impact assessment method**	CML 1999
Impact per product unit conventional	0.00081 kg SO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.001 kg SO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	34.02 kg SO2 eq./ha * y-1	**Productivity conventional**	42'000 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	29 kg SO2 eq./ha * y-1	**Productivity organic**	29'000 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 93 (Williams et al. 2010) Remark:

Crop	Potato	**Relative difference per product unit (basis = conv)**	-72%	**Relative difference productivity (basis = conv)**	-31%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	SUNDIAL simulation program (Smith et al., 1996)
Impact category	Pesticide use	**Relative difference per area and year (basis = conv)**	-81%	**Impact assessment method**	?
Impact per product unit conventional	0.00036 dose ha/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.0001 dose ha/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	15.12 dose ha/ha * y-1	**Productivity conventional**	42'000 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	2.9 dose ha/ha * y-1	**Productivity organic**	29'000 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 94 (Williams et al. 2010) Remark:

Crop	Potato	**Relative difference per product unit (basis = conv)**	20%	**Relative difference productivity (basis = conv)**	-31%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	SUNDIAL simulation program (Smith et al., 1996)
Impact category	Abiotic resource use	**Relative difference per area and year (basis = conv)**	-17%	**Impact assessment method**	CML 1999
Impact per product unit conventional	0.0001 kg antimony eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.00012 kg antimony eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	4.2 kg antimony eq./ha * y-1	**Productivity conventional**	42'000 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	3.48 kg antimony eq./ha * y-1	**Productivity organic**	29'000 kg/ha	**Uncertainty analysis on results**	no

Arable Crops Sample 95 (Williams et al. 2010) Remark:

Crop	Potato	**Relative difference per product unit (basis = conv)**	142%	**Relative difference productivity (basis = conv)**	-31%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions soils**	SUNDIAL simulation program (Smith et al., 1996)
Impact category	Land use	**Relative difference per area and year (basis = conv)**	-	**Impact assessment method**	-
Impact per product unit conventional	2.4e-005 ha/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	5.8e-005 ha/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	- -	**Productivity conventional**	42'000 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	- -	**Productivity organic**	29'000 kg/ha	**Uncertainty analysis on results**	no

Bos 2007 Netherlands

Data source: Model farms for different farm types, data origin not further specified

Fruit, Vegtable or Nut Sample 1 (Bos 2007) Remark:

Fruit / Vegetable / Nut	Pea	**Relative difference per product unit (basis = conv)**	-41%	**Relative difference productivity (basis = conv)**	?
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	?
Impact category	GWP	**Relative difference per area and year (basis = conv)**	?	**Impact assessment method**	?
Impact per product unit conventional	0.974 kg CO2 eq. / kg (DM)	**Significant difference (area and year)?**	-	**Site specific emission- and characterization factors used**	?
Impact per product unit organic	0.575 kg CO2 eq. / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	?
Impact per area and year conventional	? -	**Productivity conventional**	? ?	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	? -	**Productivity organic**	? ?	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 2 (Bos 2007) Remark:

Fruit / Vegetable / Nut	Leek	**Relative difference per product unit (basis = conv)**	29%	**Relative difference productivity (basis = conv)**	?
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	?
Impact category	GWP	**Relative difference per area and year (basis = conv)**	?	**Impact assessment method**	?
Impact per product unit conventional	0.181 kg CO2 eq. / kg (DM)	**Significant difference (area and year)?**	-	**Site specific emission- and characterization factors used**	?
Impact per product unit organic	0.234 kg CO2 eq. / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	?
Impact per area and year conventional	? -	**Productivity conventional**	? ?	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	? -	**Productivity organic**	? ?	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 3 (Bos 2007) Remark:

Fruit / Vegetable / Nut	Lettuce	**Relative difference per product unit (basis = conv)**	16%	**Relative difference productivity (basis = conv)**	?
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	?
Impact category	GWP	**Relative difference per area and year (basis = conv)**	?	**Impact assessment method**	?
Impact per product unit conventional	0.049 kg CO2 eq. / kg (DM)	**Significant difference (area and year)?**	-	**Site specific emission- and characterization factors used**	?
Impact per product unit organic	0.057 kg CO2 eq. / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	?
Impact per area and year conventional	? -	**Productivity conventional**	? ?	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	? -	**Productivity organic**	? ?	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 4 (Bos 2007) Remark:

Fruit / Vegetable / Nut	Beans	**Relative difference per product unit (basis = conv)**	-23%	**Relative difference productivity (basis = conv)**	?
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	?
Impact category	GWP	**Relative difference per area and year (basis = conv)**	?	**Impact assessment method**	?
Impact per product unit conventional	0.593 kg CO2 eq. / kg (DM)	**Significant difference (area and year)?**	-	**Site specific emission- and characterization factors used**	?
Impact per product unit organic	0.456 kg CO2 eq. / kg (DM)	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	?
Impact per area and year conventional	? -	**Productivity conventional**	? ?	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	? -	**Productivity organic**	? ?	**Uncertainty analysis on results**	no

de Backer 2009 Belgium

Data source: primary data assessed on 1 organic / 1 conventional agricultural research institute

Fruit, Vegtable or Nut Sample 5 (de Backer 2009) Remark:

Fruit / Vegetable / Nut	Leek	**Relative difference per product unit (basis = conv)**	13%	**Relative difference productivity (basis = conv)**	-27%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Brentrup et al. (2000, 2003)
Impact category	Abiotic resource use	**Relative difference per area and year (basis = conv)**	-17%	**Impact assessment method**	CML01
Impact per product unit conventional	0.000155 kg Sb eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.000175 kg Sb eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	5.8125 kg Sb eq./ha*y-1	**Productivity conventional**	37500 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	4.8125 kg Sb eq./ha*y-1	**Productivity organic**	27500 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 6 (de Backer 2009) Remark:

Fruit / Vegetable / Nut	Leek	**Relative difference per product unit (basis = conv)**	-54%	**Relative difference productivity (basis = conv)**	-27%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Brentrup et al. (2000, 2003)
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-66%	**Impact assessment method**	CML01
Impact per product unit conventional	0.0944 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.0435 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	3540.0000 kg CO2 eq./ha*y-1	**Productivity conventional**	37500 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	1196.2500 kg CO2 eq./ha*y-1	**Productivity organic**	27500 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 7 (de Backer 2009) Remark:

Fruit / Vegetable / Nut	Leek	**Relative difference per product unit (basis = conv)**	17%	**Relative difference productivity (basis = conv)**	-27%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Brentrup et al. (2000, 2003)
Impact category	Ozone depletion	**Relative difference per area and year (basis = conv)**	-14%	**Impact assessment method**	CML01
Impact per product unit conventional	3.06e-008 kg CFC eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	3.59e-008 kg CFC eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	0.0011 kg CFC eq./ha*y-1	**Productivity conventional**	37500 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0.0010 kg CFC eq./ha*y-1	**Productivity organic**	27500 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 8 (de Backer 2009) Remark:

Fruit / Vegetable / Nut	Leek	**Relative difference per product unit (basis = conv)**	-76%	**Relative difference productivity (basis = conv)**	-27%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Brentrup et al. (2000, 2003)
Impact category	Human toxicity	**Relative difference per area and year (basis = conv)**	-82%	**Impact assessment method**	CML01
Impact per product unit conventional	0.0307 kg 1,4 DB eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.00748 kg 1,4 DB eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	1151.2500 kg 1,4 DB eq./ha*y-1	**Productivity conventional**	37500 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	205.7000 kg 1,4 DB eq./ha*y-1	**Productivity organic**	27500 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 9 (de Backer 2009) Remark:

Fruit / Vegetable / Nut	Leek	**Relative difference per product unit (basis = conv)**	-99%	**Relative difference productivity (basis = conv)**	-27%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Brentrup et al. (2000, 2003)
Impact category	Terrestrial ecotoxicity	**Relative difference per area and year (basis = conv)**	-100%	**Impact assessment method**	CML01
Impact per product unit conventional	0.00691 kg 1,4 DB eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	3.53e-005 kg 1,4 DB eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	259.1250 kg 1,4 DB eq./ha*y-1	**Productivity conventional**	37500 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0.9707 kg 1,4 DB eq./ha*y-1	**Productivity organic**	27500 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 10 (de Backer 2009) Remark:

Fruit / Vegetable / Nut	Leek	**Relative difference per product unit (basis = conv)**	30%	**Relative difference productivity (basis = conv)**	-27%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Brentrup et al. (2000, 2003)
Impact category	Photochemical oxidation	**Relative difference per area and year (basis = conv)**	-5%	**Impact assessment method**	CML01
Impact per product unit conventional	5.66e-006 kg C2H4 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	7.34e-006 kg C2H4 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	0.2123 kg C2H4 eq./ha*y-1	**Productivity conventional**	37500 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0.2019 kg C2H4 eq./ha*y-1	**Productivity organic**	27500 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 11 (de Backer 2009) Remark:

Fruit / Vegetable / Nut	Leek	**Relative difference per product unit (basis = conv)**	-15%	**Relative difference productivity (basis = conv)**	-27%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Brentrup et al. (2000, 2003)
Impact category	Acidification	**Relative difference per area and year (basis = conv)**	-38%	**Impact assessment method**	CML01
Impact per product unit conventional	0.00045 kg SO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.000382 kg SO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	16.8750 kg SO2 eq./ha*y-1	**Productivity conventional**	37500 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	10.5050 kg SO2 eq./ha*y-1	**Productivity organic**	27500 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 12 (de Backer 2009) Remark:

Fruit / Vegetable / Nut	Leek	**Relative difference per product unit (basis = conv)**	3%	**Relative difference productivity (basis = conv)**	-27%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Brentrup et al. (2000, 2003)
Impact category	Eutrophication	**Relative difference per area and year (basis = conv)**	-24%	**Impact assessment method**	CML01
Impact per product unit conventional	0.000674 kg PO4 3- eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.000694 kg PO4 3- eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	25.2750 kg PO4 3- eq./ha*y-1	**Productivity conventional**	37500 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	19.0850 kg PO4 3- eq./ha*y-1	**Productivity organic**	27500 kg/ha	**Uncertainty analysis on results**	no

Juraske 2011 Spain

Data source: Typical production conditions from a Spanish orange production region

Fruit, Vegtable or Nut Sample 13 (Juraske 2011) Remark:

Fruit / Vegetable / Nut	Orange	**Relative difference per product unit (basis = conv)**	-99.5%	**Relative difference productivity (basis = conv)**	0%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	-
Impact category	Human toxicity	**Relative difference per area and year (basis = conv)**	-100%	**Impact assessment method**	USEtox
Impact per product unit conventional	4.40E-09 DALY/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	-
Impact per product unit organic	2.02E-11 DALY/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	0.0001320 DALY/ha*y-1	**Productivity conventional**	30000 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0.0000006 DALY/ha*y-1	**Productivity organic**	30000 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 14 (Juraske 2011) Remark:

Fruit / Vegetable / Nut	Orange	**Relative difference per product unit (basis = conv)**	-100%	**Relative difference productivity (basis = conv)**	0%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	-
Impact category	Freshwater ecotoxicity	**Relative difference per area and year (basis = conv)**	-100%	**Impact assessment method**	USEtox
Impact per product unit conventional	9.40E-01 PAF m3 d/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	-
Impact per product unit organic	1.58E-07 PAF m3 d/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	28200 PAF m3 d/ha*y-1	**Productivity conventional**	30000 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0.0047 PAF m3 d/ha*y-1	**Productivity organic**	30000 kg/ha	**Uncertainty analysis on results**	no

Kavargiris 2009 Greece

Data source: primary data assessed on 9 organic / 9 conventional farms

Fruit, Vegtable or Nut Sample 15 (Kavargiris 2009) Remark:

Fruit / Vegetable / Nut	Grape	**Relative difference per product unit (basis = conv)**	7%	**Relative difference productivity (basis = conv)**	-31%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	-
Impact category	Energy demand	**Relative difference per area and year (basis = conv)**	-27%	**Impact assessment method**	cumulative energy demand
Impact per product unit conventional	2887 MJ/t	**Significant difference (area and year)?**	P < 0.05 (only differnces in total energy tested)	**Site specific emission- and characterization factors used**	-
Impact per product unit organic	3076 MJ/t	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	42504 MJ/ha*y-1	**Productivity conventional**	14.7 t/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	31097 MJ/ha*y-1	**Productivity organic**	10.1 t/ha	**Uncertainty analysis on results**	no

Litskas 2011 Greece

Data source: primary data assessed on 10 organic / 10 conventional orchards

Fruit, Vegtable or Nut Sample 16 (Litskas 2011) Remark:

Fruit / Vegetable / Nut	Cherry	**Relative difference per product unit (basis = conv)**	38%	**Relative difference productivity (basis = conv)**	-50%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	-
Impact category	Energy demand	**Relative difference per area and year (basis = conv)**	-31%	**Impact assessment method**	cumulative energy demand
Impact per product unit conventional	10.6 GJ/t	**Significant difference (area and year)?**	P < 0.05 (only differnces in total energy tested)	**Site specific emission- and characterization factors used**	-
Impact per product unit organic	14.6 GJ/t	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	45.62 GJ/ha*y-1	**Productivity conventional**	4.3 t/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	31.53 GJ/ha*y-1	**Productivity organic**	2.16 t/ha	**Uncertainty analysis on results**	no

Liu 2010 China

Data source: primary data assessed on 3 organic / 2 conventional farms

Fruit, Vegtable or Nut Sample 17 (Liu 2010) Remark: BJ (organic = average from two sites)

Fruit / Vegetable / Nut	Pear	**Relative difference per product unit (basis = conv)**	-52%	**Relative difference productivity (basis = conv)**	21%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	only direct emissions considered
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-42%	**Impact assessment method**	IPCC 2007 GWP100
Impact per product unit conventional	379 kg CO2 eq./t	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	yes, for N2O
Impact per product unit organic	181.1 kg CO2 eq./t	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	5685 kg CO2 eq./ha*y-1	**Productivity conventional**	15.0 t/ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	3287 kg CO2 eq./ha*y-1	**Productivity organic**	18.2 t/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 18 (Liu 2010) Remark: LN

Fruit / Vegetable / Nut	Pear	**Relative difference per product unit (basis = conv)**	-81%	**Relative difference productivity (basis = conv)**	76%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	only direct emissions considered
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-66%	**Impact assessment method**	IPCC 2007 GWP100
Impact per product unit conventional	289 kg CO2 eq./t	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	yes, for N2O
Impact per product unit organic	55.6 kg CO2 eq./t	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	5419 kg CO2 eq./ha*y-1	**Productivity conventional**	18.8 t/ha	**Sensitivity analysis on choice of LCIA method**	yes
Impact per area and year conventional	1835 kg CO2 eq./ha*y-1	**Productivity organic**	33.0 t/ha	**Uncertainty analysis on results**	no

Michos 2012 Greece

Data source: primary data assessed on 3 organic / 4 conventional farms

Fruit, Vegtable or Nut Sample 19 (Michos 2012) Remark: compared were Group 1 and 3 (only non-renewable energy)

Fruit / Vegetable / Nut	Peach	**Relative difference per product unit (basis = conv)**	51%	**Relative difference productivity (basis = conv)**	-65%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	-
Impact category	Energy demand	**Relative difference per area and year (basis = conv)**	-48%	**Impact assessment method**	cumulative energy demand
Impact per product unit conventional	4519 MJ/t	**Significant difference (area and year)?**	P < 0.05 (only differnces in total energy tested)	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	6802 MJ/t	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	147137 MJ/ha*y-1	**Productivity conventional**	32.56 t/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	76865 MJ/ha*y-1	**Productivity organic**	11.3 t/ha	**Uncertainty analysis on results**	no

Venkat 2012 USA (California)

Data source: literature data (cost and return studies)

Fruit, Vegtable or Nut Sample 20 (Venkat 2012) Remark:

Fruit / Vegetable / Nut	Blueberry	**Relative difference per product unit (basis = conv)**	-13%	**Relative difference productivity (basis = conv)**	0%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	IPCC 2006
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-13%	**Impact assessment method**	GWP100
Impact per product unit conventional	0.829 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.723 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	13009 kg CO2 eq./ha*y-1	**Productivity conventional**	15692 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	11345 kg CO2 eq./ha*y-1	**Productivity organic**	15692 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 21 (Venkat 2013) Remark: comparison of variety Fuji (conventional) with varieties Golden Delicious, McIntosh, and others (organic)

Fruit / Vegetable / Nut	Apple (case 1)	**Relative difference per product unit (basis = conv)**	42%	**Relative difference productivity (basis = conv)**	56%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	IPCC 2006
Impact category	GWP	**Relative difference per area and year (basis = conv)**	121%	**Impact assessment method**	GWP100
Impact per product unit conventional	0.188 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.267 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	1896 kg CO2 eq./ha*y-1	**Productivity conventional**	10088 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	4190 kg CO2 eq./ha*y-1	**Productivity organic**	15692 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 22 (Venkat 2014) Remark: comparison of variety Granny Smith (conventional) with varieties Granny Smith, McIntosh, and others (organic)

Fruit / Vegetable / Nut	Apple (case 2)	**Relative difference per product unit (basis = conv)**	63%	**Relative difference productivity (basis = conv)**	-64%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	IPCC 2006
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-41%	**Impact assessment method**	GWP100
Impact per product unit conventional	0.108 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.176 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	5031 kg CO2 eq./ha*y-1	**Productivity conventional**	46586 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	2959 kg CO2 eq./ha*y-1	**Productivity organic**	16813 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 23 (Venkat 2014) Remark: comparison of variety Chardonnay for conventional and organic

Fruit / Vegetable / Nut	Wine grape (case 1)	**Relative difference per product unit (basis = conv)**	-10%	**Relative difference productivity (basis = conv)**	0%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	IPCC 2006
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-10%	**Impact assessment method**	GWP100
Impact per product unit conventional	0.272 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.244 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	3658 kg CO2 eq./ha*y-1	**Productivity conventional**	13450 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	3282 kg CO2 eq./ha*y-1	**Productivity organic**	13450 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 24 (Venkat 2015) Remark: comparison of variety Cabernet Sauvignon for conventional and organic

Fruit / Vegetable / Nut	Wine grape (case 2)	**Relative difference per product unit (basis = conv)**	-13%	**Relative difference productivity (basis = conv)**	-13%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	IPCC 2006
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-24%	**Impact assessment method**	GWP100
Impact per product unit conventional	0.205 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.179 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	2642 kg CO2 eq./ha*y-1	**Productivity conventional**	12890 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	2006 kg CO2 eq./ha*y-1	**Productivity organic**	11209 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 25 (Venkat 2015) Remark:

Fruit / Vegetable / Nut	Raisin grape	**Relative difference per product unit (basis = conv)**	5%	**Relative difference productivity (basis = conv)**	0%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	IPCC 2006
Impact category	GWP	**Relative difference per area and year (basis = conv)**	5%	**Impact assessment method**	GWP100
Impact per product unit conventional	0.667 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.700 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	2990 kg CO2 eq./ha*y-1	**Productivity conventional**	4483 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	3138 kg CO2 eq./ha*y-1	**Productivity organic**	4483 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 26 (Venkat 2016) Remark:

Fruit / Vegetable / Nut	Strawberry	**Relative difference per product unit (basis = conv)**	-31%	**Relative difference productivity (basis = conv)**	-30%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	IPCC 2006
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-52%	**Impact assessment method**	GWP100
Impact per product unit conventional	0.337 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.234 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	16234 kg CO2 eq./ha*y-1	**Productivity conventional**	48172 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	7868 kg CO2 eq./ha*y-1	**Productivity organic**	33626 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 27 (Venkat 2017) Remark:

Fruit / Vegetable / Nut	Almond	**Relative difference per product unit (basis = conv)**	52%	**Relative difference productivity (basis = conv)**	-20%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	IPCC 2006
Impact category	GWP	**Relative difference per area and year (basis = conv)**	22%	**Impact assessment method**	GWP100
Impact per product unit conventional	2.479 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	3.771 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	5557 kg CO2 eq./ha*y-1	**Productivity conventional**	2242 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	6763 kg CO2 eq./ha*y-1	**Productivity organic**	1793 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 28 (Venkat 2018) Remark: comparison of variety Chandler (conventional) with variety Terminal bearing (organic)

Fruit / Vegetable / Nut	Walnut	**Relative difference per product unit (basis = conv)**	490%	**Relative difference productivity (basis = conv)**	-80%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	IPCC 2006
Impact category	GWP	**Relative difference per area and year (basis = conv)**	18%	**Impact assessment method**	GWP100
Impact per product unit conventional	0.499 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	2.945 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	2797 kg CO2 eq./ha*y-1	**Productivity conventional**	5604 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	3301 kg CO2 eq./ha*y-1	**Productivity organic**	1121 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 29 (Venkat 2019) Remark:

Fruit / Vegetable / Nut	Broccoli	**Relative difference per product unit (basis = conv)**	16%	**Relative difference productivity (basis = conv)**	-2%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	IPCC 2006
Impact category	GWP	**Relative difference per area and year (basis = conv)**	13%	**Impact assessment method**	GWP100
Impact per product unit conventional	0.353 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.409 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	5789 kg CO2 eq./ha*y-1	**Productivity conventional**	16398 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	6556 kg CO2 eq./ha*y-1	**Productivity organic**	16028 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 30 (Venkat 2020) Remark: comparison of Iceberg (conventional) with Leaf (organic)

Fruit / Vegetable / Nut	Lettuce	**Relative difference per product unit (basis = conv)**	40%	**Relative difference productivity (basis = conv)**	-41%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	IPCC 2006
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-18%	**Impact assessment method**	GWP100
Impact per product unit conventional	0.192 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.268 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	not included
Impact per area and year conventional	6887 kg CO2 eq./ha*y-1	**Productivity conventional**	35868 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	5632 kg CO2 eq./ha*y-1	**Productivity organic**	21016 kg/ha	**Uncertainty analysis on results**	no

Vermeulen 2011 Netherlands

Data source: Statistical data from the greenhouse horticulture industry

Fruit, Vegtable or Nut Sample 31 (Vermeulen 2011) Remark: Emissions without CHP system

Fruit / Vegetable / Nut	Tomato	**Relative difference per product unit (basis = conv)**	10%	**Relative difference productivity (basis = conv)**	-17%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	?
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-9%	**Impact assessment method**	?
Impact per product unit conventional	1760 kg CO2 eq./t	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	?
Impact per product unit organic	1941 kg CO2 eq./t	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	1029600 kg CO2 eq./ha*y-1	**Productivity conventional**	58.5 kg/m2 * yr-1	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	941385 kg CO2 eq./ha*y-1	**Productivity organic**	48.5 kg/m2 * yr-1	**Uncertainty analysis on results**	no

Villanueva-Rey et al. 2014 Spain

Data source: primary data assesed on one biodynamic and one conventional vineyard in the Ribeiro appelation

Fruit, Vegtable or Nut Sample 32 (Villanueva-Rey et al. 2014) Remark: comparison between conventional and biodynamic production

Fruit / Vegetable / Nut	Wine grape	**Relative difference per product unit (basis = conv)**	-74%	**Relative difference productivity (basis = conv)**	-61%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Brentrup et al. (2000)
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-90%	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.299423 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.076491 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	2909 kg CO2 eq./ha*y-1	**Productivity conventional**	9715 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	287 kg CO2 eq./ha*y-1	**Productivity organic**	3750 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 33 (Villanueva-Rey et al. 2014) Remark: comparison between conventional and biodynamic production

Fruit / Vegetable / Nut	Wine grape	**Relative difference per product unit (basis = conv)**	-90%	**Relative difference productivity (basis = conv)**	-61%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Brentrup et al. (2000)
Impact category	Eutrophication	**Relative difference per area and year (basis = conv)**	-96%	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.001805 kg PO4 3- eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.000182 kg PO4 3- eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	17.5 kg PO4 3- eq./ha*y-1	**Productivity conventional**	9715 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0.7 kg PO4 3- eq./ha*y-1	**Productivity organic**	3750 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 34 (Villanueva-Rey et al. 2014) Remark: comparison between conventional and biodynamic production

Fruit / Vegetable / Nut	Wine grape	**Relative difference per product unit (basis = conv)**	-83%	**Relative difference productivity (basis = conv)**	-61%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Brentrup et al. (2000)
Impact category	Acidification	**Relative difference per area and year (basis = conv)**	-94%	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.004027 kg SO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.000673 kg SO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	39.1 kg SO2 eq./ha*y-1	**Productivity conventional**	9715 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	2.5 kg SO2 eq./ha*y-1	**Productivity organic**	3750 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 35 (Villanueva-Rey et al. 2014) Remark: comparison between conventional and biodynamic production

Fruit / Vegetable / Nut	Wine grape	**Relative difference per product unit (basis = conv)**	-71%	**Relative difference productivity (basis = conv)**	-61%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Brentrup et al. (2000)
Impact category	Abiotic resource use	**Relative difference per area and year (basis = conv)**	-89%	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.001732 kg Sb eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.000495 kg Sb eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	16.8 kg Sb eq./ha*y-1	**Productivity conventional**	9715 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	1.9 kg Sb eq./ha*y-1	**Productivity organic**	3750 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 36 (Villanueva-Rey et al. 2014) Remark: comparison between conventional and biodynamic production

Fruit / Vegetable / Nut	Wine grape	**Relative difference per product unit (basis = conv)**	-84%	**Relative difference productivity (basis = conv)**	-61%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Brentrup et al. (2000)
Impact category	Ozone depletion	**Relative difference per area and year (basis = conv)**	-94%	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.000000 kg CFC-11 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.000000 kg CFC-11 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	0.00045 kg CFC-11 eq./ha*y-1	**Productivity conventional**	9715 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0.00003 kg CFC-11 eq./ha*y-1	**Productivity organic**	3750 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 37 (Villanueva-Rey et al. 2014) Remark: comparison between conventional and biodynamic production

Fruit / Vegetable / Nut	Wine grape	**Relative difference per product unit (basis = conv)**	-79%	**Relative difference productivity (basis = conv)**	-61%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Brentrup et al. (2000)
Impact category	Photochemical oxidation	**Relative difference per area and year (basis = conv)**	-92%	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.000141 kg C2H4 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.000030 kg C2H4 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	1.4 kg C2H4 eq./ha*y-1	**Productivity conventional**	9715 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	0.1 kg C2H4 eq./ha*y-1	**Productivity organic**	3750 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 38 (Villanueva-Rey et al. 2014) Remark: comparison between conventional and biodynamic production

Fruit / Vegetable / Nut	Wine grape	**Relative difference per product unit (basis = conv)**	-99%	**Relative difference productivity (basis = conv)**	-61%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Brentrup et al. (2000)
Impact category	Ecotox	**Relative difference per area and year (basis = conv)**	-100%	**Impact assessment method**	USEtox
Impact per product unit conventional	24.318182 CTUe/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	0.314091 CTUe/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	236251 CTUe/ha*y-1	**Productivity conventional**	9715 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	1178 CTUe/ha*y-1	**Productivity organic**	3750 kg/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 39 (Villanueva-Rey et al. 2014) Remark: comparison between conventional and biodynamic production

Fruit / Vegetable / Nut	Wine grape	**Relative difference per product unit (basis = conv)**	132%	**Relative difference productivity (basis = conv)**	-61%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Brentrup et al. (2000)
Impact category	Land use	**Relative difference per area and year (basis = conv)**	-	**Impact assessment method**	CML 2000
Impact per product unit conventional	0.959091 m2 * a-1/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	no
Impact per product unit organic	2.227273 m2 * a-1/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	- -	**Productivity conventional**	9715 kg/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	- -	**Productivity organic**	3750 kg/ha	**Uncertainty analysis on results**	no

Warner 2010 UK

Data source: primary data assessed on a total of 20 farms comprising 3 organic / 6 conventional strawberry production systems

Fruit, Vegtable or Nut Sample 40 (Warner 2010) Remark: compared were System 2 (SP) with System 5 (SP)

Fruit / Vegetable / Nut	Strawberry	**Relative difference per product unit (basis = conv)**	130%	**Relative difference productivity (basis = conv)**	-55%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	SUNDIAL model (Smith et al. 1996)
Impact category	GWP	**Relative difference per area and year (basis = conv)**	4%	**Impact assessment method**	GWP100
Impact per product unit conventional	222 kg CO2 eq./t	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	?
Impact per product unit organic	510 kg CO2 eq./t	**Life cylce system boundary**	cradle to farm gate (including on farm storage for 12 h under controlled atmosphere)	**Capital goods**	included
Impact per area and year conventional	5550 kg CO2 eq./ha*y-1	**Productivity conventional**	25 t/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	5763 kg CO2 eq./ha*y-1	**Productivity organic**	11.3 t/ha	**Uncertainty analysis on results**	no

Williams 2005 UK

Data source: farm statistical data / database data / literature data / expert judgement

Fruit, Vegtable or Nut Sample 41 (Williams 2005) Remark:

Fruit / Vegetable / Nut	Tomato	**Relative difference per product unit (basis = conv)**	104%	**Relative difference productivity (basis = conv)**	-25%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Calculated following the methods of the national inventory for nitrous oxide
Impact category	Energy demand	**Relative difference per area and year (basis = conv)**	54%	**Impact assessment method**	cumulative energy demand
Impact per product unit conventional	112 MJ/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	229 MJ/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	31360000 MJ/ha*y-1	**Productivity conventional**	280.0 t/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	48319000 MJ/ha*y-1	**Productivity organic**	211.0 t/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 42 (Williams 2006) Remark:

Fruit / Vegetable / Nut	Tomato	**Relative difference per product unit (basis = conv)**	-81%	**Relative difference productivity (basis = conv)**	-25%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Calculated following the methods of the national inventory for nitrous oxide
Impact category	GWP	**Relative difference per area and year (basis = conv)**	-86%	**Impact assessment method**	GWP100 (emission factors: CO2 = 1, CH4 = 23, N2O = 296)
Impact per product unit conventional	0.0914 kg CO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.0175 kg CO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	25592 kg CO2 eq./ha*y-1	**Productivity conventional**	280.0 t/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	3693 kg CO2 eq./ha*y-1	**Productivity organic**	211.0 t/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 43 (Williams 2006) Remark:

Fruit / Vegetable / Nut	Tomato	**Relative difference per product unit (basis = conv)**	323%	**Relative difference productivity (basis = conv)**	-25%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Calculated following the methods of the national inventory for nitrous oxide
Impact category	Eutrophication	**Relative difference per area and year (basis = conv)**	219%	**Impact assessment method**	based on NO3, PO4 and NH3 emissions quantified in terms of phosphate equivalents (1 kg NO3-N = 0.44 kg PO4, 1 kg NH3-N = 0.43 kg PO4)
Impact per product unit conventional	0.0013 kg PO43- eq/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.0055 kg PO43- eq/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	364 kg PO43- eq/ha*y-1	**Productivity conventional**	280.0 t/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	1161 kg PO43- eq/ha*y-1	**Productivity organic**	211.0 t/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 44 (Williams 2006) Remark:

Fruit / Vegetable / Nut	Tomato	**Relative difference per product unit (basis = conv)**	201%	**Relative difference productivity (basis = conv)**	-25%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Calculated following the methods of the national inventory for nitrous oxide
Impact category	Acidification	**Relative difference per area and year (basis = conv)**	127%	**Impact assessment method**	based on SO2 and NH3 emissions quantified in terms of SO2 equivalents (1 kg NH3-N = 2.3 kg SO2)
Impact per product unit conventional	0.0115 kg SO2 eq./kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.0346 kg SO2 eq./kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	3220 kg SO2 eq./ha*y-1	**Productivity conventional**	280.0 t/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	7301 kg SO2 eq./ha*y-1	**Productivity organic**	211.0 t/ha	**Uncertainty analysis on results**	no

Fruit, Vegtable or Nut Sample 45 (Williams 2006) Remark:

Fruit / Vegetable / Nut	Tomato	**Relative difference per product unit (basis = conv)**	89%	**Relative difference productivity (basis = conv)**	-25%
Landscape	Lowland	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	Calculated following the methods of the national inventory for nitrous oxide
Impact category	Abiotic resource use	**Relative difference per area and year (basis = conv)**	42%	**Impact assessment method**	CML
Impact per product unit conventional	0.096 dose ha/kg	**Significant difference (area and year)?**	no testing	**Site specific emission- and characterization factors used**	
Impact per product unit organic	0.181 dose ha/kg	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	26880 dose ha*y-1/ha*y-1	**Productivity conventional**	280.0 t/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	38191 dose ha*y-1/ha*y-1	**Productivity organic**	211.0 t/ha	**Uncertainty analysis on results**	no

Zafiriou 2012 Greece

Data source: primary data assessed on 3 organic / 5 conventional farms

Fruit, Vegtable or Nut Sample 46 (Zafiriou 2012) Remark: compared were Group 1 and 3 (only non-renewable energy)

Fruit / Vegetable / Nut	Asparagus	**Relative difference per product unit (basis = conv)**	-25%	**Relative difference productivity (basis = conv)**	-25%
Landscape	Hilly	**Significant difference (product unit)?**	no testing	**Calculation basis for N2O-emissions from soils**	-
Impact category	Energy demand	**Relative difference per area and year (basis = conv)**	-43%	**Impact assessment method**	cumulative energy demand
Impact per product unit conventional	26350 MJ/t	**Significant difference (area and year)?**	n.s. (only differences in total energy tested)	**Site specific emission- and characterization factors used**	-
Impact per product unit organic	19883 MJ/t	**Life cylce system boundary**	cradle to farm gate	**Capital goods**	included
Impact per area and year conventional	245053 MJ/ha*y-1	**Productivity conventional**	9.3 t/ha	**Sensitivity analysis on choice of LCIA method**	no
Impact per area and year conventional	139182 MJ/ha*y-1	**Productivity organic**	7.0 t/ha	**Uncertainty analysis on results**	no

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APPENDIX B

SUPPORTING INFORMATION: LIFE CYCLE INVENTORY AND CARBON AND WATER FOODPRINT OF FRUITS AND VEGETABLES: APPLICATION TO A SWISS RETAILER

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This Appendix is a reprint of the `Supporting Information' of the following published article: ***Franziska Stoessel, Ronnie Juraske, Stephan Pfister, and Stefanie Hellweg.2012. Life Cycle Inventory and Carbon and Water FoodPrint of Fruits and Vegetables: Application to a Swiss Retailer. Environmental Science and Technology 46, 3253-3262.*** *The content is reproduced "as is", however the formatting was changed and references have been updated.*

9.1 MATERIAL AND METHODS

9.1.1 PACKAGING AND OPERATION OF THE STORE

Fruits and vegetables are generally packed by the consumers using light polyethylene bags, made of LDPE (low density polyethylene). Four bags were weighted in the lab and compared with specifications of bag-suppliers. An average load of half a kg per bag-use and a short storage period in the store is assumed (Meylan, 2007). The global warming potentials (GWP) of the packaging (disposal in municipal incineration included) and store operation were calculated (shown in Table 9.1) and compared to the overall impact of fruits and vegetables from cradle to shelf.

Table 9.1 GWP of one kg of crop from cradle to shelf (packaging and operation of the store included) compared to the GWP of one kg of product from cradle to gate.

	2 bags à 2.5 g / kg of fruit or vegetable	**Store operations (electricity use for cooling, freezing, lighting) for one kg of product**	**Average impact per kg vegetable and fruit from cradle to gate**	**Total**
kg CO_2-eq. / kg of product	0.016	0.011	0.463 (without any air transport or greenhouse heating) 0.834 (with all reasonable air transport and greenhouse heating)	0.490 0.862
%	2-3	1-2	95-97	100

9.1.2 INVENTORIES

See “9.3 Selected LCI fruits and vegetables FST”. References to all specific numbers of the inventory of each single crop are indicated there.

9.1.3 YIELDS / LAND USE

Exact growing times are considered for the analyses even if the land is fallow before or after the cultivation of melons, pineapples and vegetables. No transformation of the land is included given that the fruits and vegetables are grown on long time existing crop lands, especially in Europe where most of the crops are produced in this study. The underlying classification for the ecoinvent processes used are CORINE 21 (agricultural crop land), CORINE 211 (agricultural crop land, non-irrigated) and CORINE 222a (permanent crops, orchard or berry orchard) (Keil et al., 2005; Nemecek and Kägi, 2007) for the different crops.

9.1.4 VEGETABLE SEEDLINGS

The substrata are made from peat, which is – for Europe – mostly mined in the Baltic states, Poland and Russia (Meienberg, 2005) but also in Finland and Ireland (Trinnaman and Clarke, 2004). For the vegetables grown in Switzerland or in countries north of Switzerland (Belgium, Germany, Slovakia and the Netherlands) it was assumed that 30 g peat / seedling would be transported to the Netherlands, where the seedlings are produced in heated greenhouses. Afterwards they are transported to the horticultural farms (100 g / seedling with moisture and container). For the vegetables grown south of Switzerland (Morocco included) the peat (30 g peat / seedling) was transported to the according destinations where the seedlings were produced in unheated greenhouses. The weight of the seedlings was measured on the market of Zurich and furthermore calculated from information of a truck driver and horticulturist who transported seedlings. The weight of peat and especially of the seedlings was considered constant even if in reality they vary.

For vegetable productions overseas it is assumed that they are produced on the sites where the crops are grown and the peat transport distance is assumed to be generally 4000 km (Google, 2009; Schilstra and Gerding, 2004) for seedling production in USA (for peat from Alaska), Tasmania, Mexico and Peru. All transports are modeled with a truck > 32t EURO4-class.

In a heated seedling production a plant density of 774 seedlings / m^2 with a consumption of 1 l fossil fuel / m^2 and 5 weeks was assumed. The transport, peat and fossil fuel consumption is calculated per functional unit. Note that for onion, carrots, radish and spinach no seedlings were produced.

9.1.5 FERTILIZATION

The amount of fertilizers applied, according to the tables with agricultural production means for cost calculations (Arbeitsgruppe Betriebswirtschaft VSGP, 2005), were used in the inventory. Specifications of providers (FiBL, 2007; Providers of agricultural means for production, 2011) were used to calculate the amount of active ingredients. Single nutrient fertilizers were chosen to avoid overlapping. Exact numbers are given in the inventory tables for each crop.

9.1.6 MULCH FILM

Covering the soil with mulch films in order to deprive the weed of light and water is a common biological weed control. Another reason for the use of mulch films is the thermal control of the soil, favoring a better microclimate for the plants. This technique is used in melon, strawberry, banana and pineapple production, and it was modeled with a polyethylene film (190 kg / ha) (Odet, 1985) including its disposal with different techniques in different countries. The disposal of the mulch film, used in melon, strawberry, banana and pineapple production is modeled according to scheme in Table 9.2.

Table 9.2 % of waste treated in landfills, incineration and recycling plants in the four countries where melon, strawberry, banana and pineapple production is modelled (Koehler et al., 2011).

Waste treated in (in %)	**landfill**	**incineration**	**recycling**
Spain	53	6	41
France	36	34	30
Italy	55	11	34
Greece	87	0	13

9.1.7 FLAME TREATMENT

Flame treatment is used to control weed and soil borne pests. It was modeled for eggplant, cucumber, lettuce, bell pepper, radish and tomatoes by using the representative ecoinvent process “Heat natural gas, at boiler modulating <100 kW/RER”. The consumption of gas was assumed to be 50 kg gas / ha treated area (Dierauer, 2000). The calorific value of 45.4 MJ / kg gas was used to model the energy input (Frischknecht et al., 2002). If the flame treatment is only used once in a few years the amount of gas applied is divided accordingly.

9.1.8 FARM MACHINERY USE

For fruit production, machine use is modeled using the number of times farm machinery is used to treat a particular crop during the growing season. In ecoinvent, farm machinery use is expressed in units of area treated per functional unit, and we could use the number of machinery applications and the crop yield to calculate machinery input per functional unit.

For vegetable production, machine use was based on data from farmer time budgets. Farmer time was then transformed using information on tractor working life and fuel consumption, see equation (1):

$$a_{\text{FUcrop}} = \frac{\frac{m_t}{m_{1h}}}{t_m} t_{crop} \; [ha\ kg^{-1}] \text{ (eq 1)}$$

with

a_{FUcrop} = area treated per kg of crop [ha kg^{-1}]

m_t = 3000 kg, the total mass of machine [kg] (Ecoinvent, 2008)

m_{1h} = 0.687 kg, mass of tractor used to treat 1 ha of agricultural land [kg ha^{-1}] (Ecoinvent, 2008)

t_m = 7000 h, working time per one machine life [h] (Ecoinvent, 2008)

t_{crop} = specific hours of machine work per kg of crop produced [h kg^{-1}] (Arbeitsgruppe Betriebswirtschaft VSGP, 2005)

9.1.9 HEATING OIL USE IN GREENHOUSES

In order to show seasonality related variability of fuel consumption a time-dependent energy use model for heated greenhouse production for different types of greenhouses, locations and types of crops was developed and applied (Hangartner, 2010). The model was built on the basis of SIA 380/1 norms (SIA, 2009) using energy balance equations for buildings:

$$Q_{heating} = Q_{trans} + Q_{air} - f \times Q_{solar} \ [W] \ \text{(eq 2)}$$

$$Q_{trans} = \sum k_j \times A_j \times (T_{in} - T_{out}) \ [W] \ \text{(eq 3)}$$

$$Q_{air} = n \times V \times (\rho c_p) \times (T_{in} - T_{out}) \ [W] \ \text{(eq 4)}$$

$$Q_{solar} = G \times A_W \times (f_g \tau f_s) \ [W] \ \text{(eq 5)}$$

with

$Q_{heating}$ = heating demand of a building (W)

Q_{trans} = heat transmitted through the walls (W)

Q_{air} = heat lost due to air exchange from the inside to the outside of the building (W)

Q_{solar} = heat gains from the solar irradiation (W)

f = solar heat gain coefficient (SHGC) which indicate the fraction of solar irradiation that is directly transmitted through the window or absorbed by the window and released inwards the building (-)

k_j = U-value = heat transfer coefficient through a composite element (W/m^2/K)

A_j = total cladding area (m^2)

T_{in} = inside temperature (K)

T_{out} = outside temperature (K)

n = air exchange number, i.e. the number of times the entire volume of air is replaced per hour in a building (1/h)

V = volume of the building (m^3)

ρc_p = 0.32 and is the specific volumetric energy constant for air (W/m^3/K)

G = global solar irradiation (W/m^2)

A_w = area of the windows exposed to the sun and was assumed to be the ground area of the greenhouse in our model (m^2)

f_g = glass fraction of the window (-)

τ = transmissivity of the glass for visible radiation ($\approx$0.9)

f_s = reduction by shading or impurities on the window (typically 0.6-0.8)

t_{plant} = month of planting

$t_{harvest}$ = month of harvest

From this model the total heating demand for the specific crop period (from t_{plant} to $t_{harvest}$) can be calculated per kg of crop. T_{in}, T_{out} and G vary over the growing time. $Q_{heating}$ is calculated using monthly average values and summed up over the growing period. The total heating demand is finally divided by the yield (Hangartner, 2010). The following equations (eqs 6-10) were not part of the original publication, but added to this Chapter to allow reproducibility of the data.

$$k_j = \left(\frac{1}{\alpha_i} + \sum \frac{d_i}{\lambda_i} + \frac{1}{\alpha_{out}} \right)^{-1} \quad [\mathrm{W/m2K}] \qquad \text{(eq 6)}$$

$$Q_{heating\_tot} = input\ f(T_{out}, T_{in}, G, A_w, V, A_j, d_i, \lambda_i, n, t_{harvest}, Y_{harvest}) \quad [\mathrm{MJ/kg}] \qquad \text{(eq 7)}$$

$$\mathrm{Q_{heating\_tot}} = \sum_{t=t_{plant}}^{t_{harvest}} \mathrm{Q_{heating}} \quad [\mathrm{MJ}] \qquad \text{(eq 8)}$$

$$\text{Energy input/ground area} = \frac{\mathrm{Q_{heating\_tot}}}{\mathrm{A_{ground}}} \quad [\mathrm{MJ/m^2}] \qquad \text{(eq 9)}$$

$$\text{Energy input/production} = \frac{\mathrm{Q_{heating\_tot}}}{\mathrm{Y_{harvest}}} \quad [\mathrm{MJ/kg}] \qquad \text{(eq 10)}$$

For the modeling of lettuce in the example following parameters from a greenhouse in Hinwil, Switzerland were used:

GLOBALS as described in the master thesis (Hangartner, 2010)		
α_i	alpha_in=8	heat transfer coefficient inside
α_{out}	alpha_out=20	heat transfer coefficient outside
f	fract_use_heat=0.609	fractional use of heat gains
τ	tau=0.9	transmissivity of glass (assumed to be constant)
f_s	0.7	reduction by shading impurities on the window
	Q_internal=0	[W/m²]
f_g	glass_fraction_greenhouse=0.99	[%]
ρ cp	0.32	specific volumetric energy constant for air [W/m³K]
DEFAULT VALUES		
A_w	ground_area_greenhouse=46800 (Christ, 2009)	[m²]
V	volume_greenhouse=259506 (Christ, 2009)	[m³]
A_j	total_area_greenhouse=54978.2 (Christ, 2009)	[m²]
d_i	thickness_wall=0.0225 (Hangartner, 2010)	[m]
λ_i	lambda_wall=0.9 (Hangartner, 2010)	conductivity of window [W/mK]
n	n=0.24 (Dannecker et al., 2002)	ventilation rate (x/h) [-]
T_{in}	temp_in=12 (Wonneberger et al., 2004)	optimal growing temp [°C]
	crop_time=3 (Arbeitsgruppe Betriebswirtschaft VSGP, 2005)	month growing
$Y_{harvest}$	crop_yield=195897 (Arbeitsgruppe Betriebswirtschaft VSGP, 2005)	[kg]
T_{out}	temperature_jan=0.1 (European Commission, 2008) temperature_feb=1.9 temperature_mar=5.4 temperature_apr=8.9 temperature_may=13.9 temperature_jun=17.2 temperature_jul=18.7	[°C]

	temperature_aug=18.3 temperature_sep=14.3 temperature_oct=10.7 temperature_nov=4.5 temperature_dec=1.2	
G	solarrad_jan=72 solarrad_feb=107 solarrad_mar=157 solarrad_apr=192 solarrad_may=203 solarrad_jun=219 solarrad_jul=229 solarrad_aug=211 solarrad_sep=168 solarrad_oct=124 solarrad_nov=75 solarrad_dec=57	[W/m^2](European Commission, 2008)

9.1.10 IRRIGATION

Irrigation data for all crops from different locations were not available from one source. Therefore Table 9.3 presents the specific sources. “Numbers in black” were calculated according to the method presented in Pfister et al. (2011a) using yields from the LCI. “Numbers in green” use the crop water requirement data from Chapagain and Hoekstra (2004) and deduct an average amount of rainfall (Mühr, 2010) during the specific cropping period or nothing if it’s a greenhouse production, to estimate irrigation water consumption. “Numbers in green” for productions in Switzerland use irrigation data from szg (Arbeitsgruppe Betriebswirtschaft VSGP, 2005). “Numbers in blue” are calculated as a proxy using the irrigation and yield data from Chapagain and Hoekstra (2004).

Table 9.3 Source of irrigation data for every crop from different locations. The meaning of the colors (black, blue and green) is described in the text above.

Product	Country of origin	m^3 / kg
Banana	Costa Rica	0.106
Banana	Ecuador	0.142
Banana	Columbia	0.079
Strawberry	France	0.247
Strawberry	Switzerland	0.007
Strawberry	Spain	0.230
Lettuce	Belgium	0.078
Lettuce	France	0.109
Lettuce	Italy	0.185
Lettuce	The Netherlands	0.062
Lettuce	Switzerland	0.016
Lettuce	Spain	0.006
Leek, onion, carrot	Italy	0.048
Leek, onion, carrot	Spain	0.073
Avocado	Chile	0.000
Avocado	Israel	0.932
Avocado	Peru	0.876

Product	Country of origin	m³ / kg
Avocado	Spain	0.598
Avocado	South Africa	0.721
Kiwi	Italy	0.126
Kiwi	New Zealand	0.080
Pineapple	Costa Rica	0.022
Pineapple	Ecuador	0.299
Pineapple	Ghana	0.013
Asparagus	Costa Rica	0.854
Asparagus	France	2.028
Asparagus	Greece	2.113
Asparagus	Holland / Deutschland	0.398
Asparagus	Israel	3.213
Asparagus	Morocco	3.386
Asparagus	Mexico	3.777
Asparagus	Middle America	3.777
Asparagus	Peru	1.424
Asparagus	Switzerland	0.013
Asparagus	Spain	1.952
Asparagus	Hungary	1.136
Fennel, cauliflower, broccoli	France	0.062
Fennel, cauliflower, broccoli	Italy	0.090
Fennel, cauliflower, broccoli	Spain	0.166
Spinach	Italy	0.014
Spinach	Switzerland	0.008
Spinach	Spain	0.037
Broccoli	Italy	0.073
Broccoli	Switzerland	0.033
Broccoli	Spain	0.012
Fennel	Italy	0.140
Fennel	Switzerland	0.050
Fennel	Spain	0.320
Cauliflower	Italy	0.056
Cauliflower	Switzerland	0.026
Cauliflower	Spain	0.056
Potato	Other countries	0.179
Potato	Israel	0.190
Potato	Morocco	0.325
Potato	Switzerland	0.000
Potato	Spain	0.202
Apple	New Zealand	0.070
Apple	Switzerland	0.020
Pear	Switzerland	0.028
Pear	South Africa	0.238
Melon	France	0.032

Product	Country of origin	m^3 / kg
Melon	Italy	0.039
Melon	North Africa	0.223
Melon	Spain	0.065
Melon	South America	0.080
Grape	France	0.093
Grape	Greece	0.187
Grape	Italy	0.107
Grape	North Africa	0.360
Grape	Spain	0.199
Grape	South Africa	0.236
Grape	South America	0.056
Citrus	Argentina	0.050
Citrus	Florida	0.147
Citrus	Israel	0.218
Citrus	Italy	0.062
Citrus	Spain	0.148
Citrus	South Africa	0.238
Eggplant	The Netherlands	0.008
Eggplant	Switzerland	0.050
Eggplant	Spain	0.152
Green bell pepper	The Netherlands	0.021
Green bell pepper	Switzerland	0.038
Green bell pepper	Spain	0.005
Zucchini	The Netherlands	0.005
Zucchini	Switzerland	0.016
Zucchini	Spain	0.010
Tomato	Italy	0.106
Tomato	Morocco	0.013
Tomato	The Netherlands	0.008
Tomato	Switzerland	0.002
Tomato	Spain	0.010
Tomato	Italy	0.106
Tomato	Morocco	0.092
Tomato	The Netherlands	0.008
Tomato	Switzerland	0.002
Tomato	Spain	0.009
Cucumber	Italy	0.161
Cucumber	Morocco	0.133
Cucumber	The Netherlands	0.008
Cucumber	Switzerland	0.030
Cucumber	Spain	0.064

9.1.11 DISTANCES AND MEANS OF TRANSPORTATION

The transportation scheme contains generally one to four transportation steps. The fourth step comprises generally 100 km fine distribution within Switzerland per kg of product. Steps 1-3 are assembled depending on the country of origin and the transportation mode. As an example the transportation of a product from Peru is described as follows: The 1st step is the transport from the place of production to the port or the airport, the 2nd step is the oversea travel by ship or airplane, in case of transportation by ship there is a 3rd step from the port to Switzerland by truck and the 4th step is the fine distribution within Switzerland. The scheme is presented in Table 9.4. The distances are measured with online tools (Google, 2009; myclimate, 2009; News, 2009; Rudd, 2009; World Port Source, 2009) and are presented in Table 9.5.

Table 9.4 Scheme with means and routes of transportation for the fruits and vegetables from the place of production to the point of sale.

			Products from Switzerland (CH)	**Products from Europe (EU)**	**Products from Overseas**	
1st step	truck				place of production → (air)port	
2nd step	ship	air-plane			port → Rotterdam or Genoa	airport → CH
3rd step	truck			place of production → CH	Genoa or Rotterdam → CH	
4th step	truck		overall 100 km in CH to the point of sale	overall 100 km in CH to the point of sale	overall 100 km in CH to the point of sale	

Table 9.5 Transportation means and distances.

1st step		2nd step		2nd step		3rd step		4th step	
truck		**ship**		**airplane**		**truck**		**truck**	
place of production to port / airport	**km**	**port country of origin to port Europe (Rotterdam / Genoa)**	**km**	**airport country of origin to airport Switzerland**	**km**	**port Europe (Rotterdam / Genoa) or place of production in Europe to Switzerland**	**km**	**general distribution distance within Switzerland**	**km**
Argentina (general)	600	Argentina (Comodoro Rivadavia - Rotterdam)	12'973			Argentina (Rotterdam - CH)	758	all products, all countries of origin	100
						Belgium	640		
Brazil (Birigui - Paranagua)	700	Brazil (Paranagua - Rotterdam)	10'282			Brazil (Rotterdam - CH)	758		
Brazil (Birigui - Paranagua airport)	900			Brazil Flug (Paranagua - CH)	9'926				
Caribbean (general)	150	Caribbean (Dom.Rep.Barahona - Rotterdam)	7'604			Caribbean (Rotterdam - CH)	758		
Chile (general)	500	Chile (Valparaiso - Rotterdam)	13'807			Chile (Rotterdam - CH)	758		
Colombia (general)	50	Colombia (Santa Marta - Rotterdam)	8'293			Colombia (Rotterdam - CH)	758		
Costa Rica (general)	100	Costa Rica (Quepos - Rotterdam)	9'738			Costa Rica (Rotterdam - CH)	758		
Ecuador (general)	400	Ecuador (Guayaquil - Rotterdam)	10'514			Ecuador (Rotterdam - CH)	758		
Egypt (general)	500	Egypt (Alexandria - Genoa)	2'345	Egypt (Alexandria - CH)	2'567	Egypt (Genoa - CH)	444		
						France	733		
						Germany	729		
Ghana (general)	100	Ghana (Tema - Rotterdam)	7'358			Ghana (Rotterdam - CH)	758		
Greece (Grevena - Athens)	500	Greece (Athens - Genoa)	1'800			Greece (Genoa - CH)	444		
						Greece (Grevena - CH)	2'120		
						Hungary (Budapest - CH)	1'251		
India (general, around Patna - Calcutta)	500	India (Calcutta - Rotterdam)	14'747			India (Rotterdam - CH)	758		
Israel (general)	100	Israel (Ashdod - Genoa)	2'782			Israel (Genoa - CH)	444		
						Italy	893		
Mexico (general)	200	Mexico (Guayamas - Rotterdam)	13'351	Mexiko Flug (Guaymas - CH via San Francisco)	10'903	Mexico (Rotterdam - CH)	758		
						Morocco	2'404		
						Netherlands	812		
New Zealand (general)	300	New Zealand (Wellington - Rotterdam)	20'987			New Zealand (Rotterdam - CH)	758		
Palestine (Karama, Jordanien - Haifa)	100	Palestine (Haifa - Genoa)	2'771			Palestine (Genoa - CH)	444		
Peru (Ica - Pisco)	100	Peru (Pisco - Rotterdam)	11'653			Peru (Rotterdam - CH)	758		
Peru (Ica - Lima)	300			Peru (Lima - CH)	10'680				
						Slovakia	1'044		
South Africa (Beaufort West - Cape Town)	434	South Africa (Cape Town - Rotterdam)	11'414			South Africa (Rotterdam - CH)	758		
						Spain (Valencia - Spreitenbach)	1'398		
Tasmania (general)	500	Tasmania (Devonport - Rotterdam)	20'683			Tasmania	758		
Uruguay (general)	300	Uruguay (Montevideo - Rotterdam)	11'564			Uruguay (Rotterdam - CH)	758		
USA (general)	200	USA (San Francisco - Rotterdam)	14'975	USA Flug (San Francisco - CH)	9'388	USA (Rotterdam - CH)	758		
USA Florida (Lakeland - Miami)	350	USA Florida (Miami - Rotterdam)	7'610			USA Florida (Rotterdam - CH)	758		

9.1.12 COOLING DURING TRANSPORTATION

Container transport is assumed to be the transportation mode. During the transportation all containers are cooled with a separate aggregate. To calculate the energy use, transportation time is needed which is calculated in the following way: The effective travel time is calculated from the velocity of the vehicle (Table 9.6) and the particular distance and the different steps are summed up. Waiting times are included by generally adding 24 h at every change of vehicle, but max. 48 h.

Table 9.6 Assumed velocities of transportation vehicles.

Means of transport	Average velocity
Truck in western countries	50 km / h
Truck in emerging economies	40 km / h
Freight ship	37 km / h
Airfreight	flight time according to flight schedules from air flight companies
Waiting time	24 h at each vehicle change (max. 48 h)

9.1.13 ELECTRICITY USE FOR STORAGE

According to the literature (Blanke and Burdick, 2005) the energy use for apple storage at 1 °C is 5.4 MJ / t / day. Most of the crops are stored at this temperature. This information was used to estimate an energy use for all the crops, but at their ideal storage temperature and the maximal storage time (George and Eghbal, 2003; Hornischer et al., 2005; Konrad and Knapp, 2011; Konrad and Willging, 2011; Lichtenhahn et al., 2003; Wonneberger et al., 2004). Detailed information is shown in Table 9.7. The values used for storage correspond to the energy use in storages (20 – 105 kWh / m^3*a), shown in the literature (Institut für Kälte- Klima- Energietechnik (Essen), 2005).

Table 9.7 Storage time, temperature and storage energy per kg of crop.

	Maximum storage time in months (30 days)	**Storage temperature in °C**	**Storage energy MJ/t/day**	**kWh / kg product / max. storage time**	**Reference**
Eggplant	0.3	8-10	2.7	0.0075	estimated
Cauliflower	1	(-0.5)-0	5.4	0.0450	(World Port Source, 2009)
Broccoli	1	0-0.5	5.4	0.0450	(World Port Source, 2009)
Fennel	0.75	0-1	5.4	0.0345	(World Port Source, 2009)
Cucumber	0.3	11	2.7	0.0075	estimated
Cabbage	3-6	1-2	5.4	0.2025	(World Port Source, 2009)
Carrot	7	0-1	5.4	0.3150	(World Port Source, 2009)
Lettuce	0.3	0-1	5.4	0.0150	(World Port Source, 2009)
Radish	0.3	0-1	5.4	0.0150	(World Port Source, 2009)
Celery root	7	0-(-0.5)	5.4	0.3150	(World Port Source, 2009)
White asparagus	0.03-0.06	2-4	4	0.0022	estimated
Green asparagus	0.03-0.06	2-4	4	0.0022	estimated
Spinach	0.15	-1-(-0.5)	5.4	0.0075	(World Port Source, 2009)
Zucchini	0.24	7-10	2.7	0.0053	estimated
Onion	>5	0	5.4	0.3150	(World Port Source, 2009)
Bell pepper	0.5	8-9	2.7	0.0113	estimated
Tomato	0.5	10-12	2.7	0.0113	estimated
Potato	8	4-5	4	0.2667	estimated
Apple	5	-1	5.4	0.2250	(World Port Source, 2009)
Pear	7	-1	5.4	0.3150	(World Port Source, 2009)
Grape	2	-0.5	5.4	0.0900	(World Port Source, 2009)
Melon	0.6	5	2.7	0.0150	estimated
Citrus	2.1	9	2.7	0.0488	estimated
Strawberry	0.2	-1	5.4	0.0075	(World Port Source, 2009)
Banana	0.9	13	1.9	0.0148	estimated
Kiwi	8	0	5.4	0.3600	(World Port Source, 2009)
Avocado	0.9	8	3.2	0.0249	estimated
Papaya	1	10	2.7	0.0225	estimated
Pineapple	0.6	9.75	2.7	0.0128	estimated

9.2 RESULTS

9.2.1 RECIPE RESULTS

See Table 9.8.

Table 9.8 Results of all LCI assessed with ReCiPe (H/A) (Goedkoop et al., 2009). GH = greenhouse, cells are highlighted using a color scale with red indicating high values and green indicating low values and the results are ordered from the highest to the lowest sum.

Method		ReCiPe Endpoint (H) V1.05 / World ReCiPe H/A																	
Impact categorie		Sum	Climate change Human Health	Ozone depletion	Human toxicity	Photochemical oxidant formation	Particulate matter formation	Ionising radiation	Climate change Ecosystems	Terrestrial acidification	Freshwater eutrophication	Terrestrial ecotoxicity	Freshwater ecotoxicity	Marine ecotoxicity	Agricultural land occupation	Urban land occupation	Natural land transformation	Metal depletion	Fossil depletion
Unit		Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt
Green asparagus (Air transport)	Mexico	1.49E+00	5.59E-01	1.30E-04	2.68E-02	7.78E-05	1.51E-01	1.31E-03	4.98E-02	1.60E-04	2.41E-05	3.32E-04	4.36E-06	1.13E-08	2.94E-02	7.29E-04	4.07E-03	2.58E-04	6.66E-01
Green asparagus (Air transport)	Peru	1.38E+00	5.25E-01	1.24E-04	1.79E-02	7.36E-05	1.39E-01	6.09E-04	4.67E-02	1.52E-04	1.61E-05	3.26E-04	3.41E-06	8.18E-09	2.89E-02	4.43E-04	3.93E-03	1.40E-04	6.20E-01
White asparagus (Air transport)	Peru	1.33E+00	5.10E-01	1.19E-04	1.49E-02	7.29E-05	1.33E-01	4.35E-04	4.54E-02	1.41E-04	1.26E-05	1.03E-04	2.51E-06	6.96E-09	1.74E-02	3.71E-04	3.89E-03	1.04E-04	6.09E-01
Green asparagus (Air transport)	USA	1.27E+00	4.80E-01	1.12E-04	2.10E-02	6.69E-05	1.30E-01	9.28E-04	4.27E-02	1.40E-04	1.91E-05	3.21E-04	3.71E-06	9.04E-09	2.91E-02	5.53E-04	3.50E-03	1.93E-04	5.67E-01
White asparagus (Air transport)	Costa Rica	1.19E+00	4.54E-01	1.06E-04	1.38E-02	6.55E-05	1.21E-01	4.15E-04	4.04E-02	1.27E-04	1.18E-05	9.61E-05	2.36E-06	6.36E-09	1.74E-02	3.43E-04	3.45E-03	9.96E-05	5.41E-01
Papaya (Air transport)	Brazil	1.16E+00	4.49E-01	1.07E-04	9.76E-03	6.40E-05	1.11E-01	1.76E-04	4.00E-02	1.15E-04	7.36E-06	5.80E-05	1.32E-06	4.98E-09	1.08E-03	2.32E-04	3.54E-03	3.99E-05	5.44E-01
Radish (GH heated)	Switzerland	4.91E-01	2.00E-01	5.32E-05	9.14E-03	9.74E-06	2.42E-02	1.97E-04	1.78E-02	2.81E-05	8.32E-06	1.91E-05	1.09E-06	3.40E-09	3.00E-04	7.87E-05	1.19E-03	6.79E-05	2.37E-01
Lettuce (GH heated)	Netherlands	4.48E-01	1.81E-01	4.76E-05	9.97E-03	9.34E-06	2.33E-02	2.29E-04	1.61E-02	2.66E-05	9.76E-06	1.83E-05	1.19E-06	3.71E-09	5.44E-04	8.82E-05	1.06E-03	6.78E-05	2.15E-01
Lettuce (GH heated)	Belgium	4.46E-01	1.81E-01	4.74E-05	9.97E-03	9.26E-06	2.32E-02	2.33E-04	1.61E-02	2.65E-05	9.77E-06	1.82E-05	1.19E-06	3.71E-09	5.46E-04	8.84E-05	1.05E-03	6.80E-05	2.14E-01
Lettuce (GH heated)	Switzerland	4.36E-01	1.77E-01	4.65E-05	9.56E-03	8.78E-06	2.22E-02	2.12E-04	1.57E-02	2.57E-05	9.42E-06	1.74E-05	1.15E-06	3.55E-09	5.33E-04	7.46E-05	1.04E-03	6.23E-05	2.10E-01
Iceberg lettuce (Air transport)	Egypt	3.21E-01	1.24E-01	2.93E-05	3.30E-03	1.82E-05	3.23E-02	7.36E-05	1.10E-02	3.32E-05	2.58E-06	1.66E-05	4.42E-07	1.58E-09	7.70E-04	8.05E-05	9.51E-04	2.04E-05	1.49E-01
Eggplant (GH heated)	Netherlands	3.05E-01	1.21E-01	3.02E-05	8.94E-03	6.84E-06	2.14E-02	1.97E-04	1.08E-02	2.98E-05	9.75E-06	1.93E-05	1.07E-06	3.39E-09	5.85E-04	6.23E-05	6.89E-04	4.88E-05	1.41E-01
Eggplant (GH heated)	Belgium	3.03E-01	1.20E-01	3.00E-05	8.89E-03	6.73E-06	2.12E-02	1.96E-04	1.07E-02	2.96E-05	9.72E-06	1.91E-05	1.06E-06	3.37E-09	5.85E-04	6.06E-05	6.85E-04	4.81E-05	1.40E-01
Eggplant (GH heated)	Switzerland	2.96E-01	1.18E-01	2.92E-05	8.86E-03	6.31E-06	2.05E-02	2.05E-04	1.05E-02	2.90E-05	9.72E-06	1.86E-05	1.05E-06	3.34E-09	5.91E-04	5.94E-05	6.67E-04	4.78E-05	1.36E-01
Green asparagus (freight ship transport)	Mexico	2.84E-01	8.83E-02	1.87E-05	1.79E-02	1.36E-05	4.37E-02	1.16E-03	7.85E-03	4.95E-05	1.79E-05	2.73E-04	3.19E-06	6.68E-09	2.93E-02	5.12E-04	3.14E-04	2.31E-04	9.39E-02
Green asparagus (freight ship transport)	USA	2.45E-01	7.63E-02	1.70E-05	1.35E-02	1.25E-05	4.00E-02	8.03E-04	6.79E-03	4.72E-05	1.39E-05	2.70E-04	2.72E-06	5.18E-09	2.91E-02	3.69E-04	2.89E-04	1.70E-04	7.73E-02
Green asparagus (freight ship transport)	Israel	2.42E-01	7.56E-02	1.62E-05	1.54E-02	1.05E-05	3.54E-02	9.81E-04	6.73E-03	4.12E-05	1.55E-05	2.70E-04	2.91E-06	5.66E-09	2.92E-02	4.36E-04	2.52E-04	1.99E-04	7.75E-02
White asparagus	Morocco	2.31E-01	7.37E-02	1.43E-05	1.56E-02	1.04E-05	3.10E-02	1.03E-03	6.56E-03	3.12E-05	1.48E-05	5.10E-05	2.35E-06	5.56E-09	1.78E-02	4.69E-04	2.64E-04	2.08E-04	8.47E-02
Cucumber (GH heated)	Netherlands	2.19E-01	8.83E-02	2.33E-05	4.61E-03	4.85E-06	1.19E-02	9.92E-05	7.86E-03	1.34E-05	4.40E-06	9.29E-06	5.52E-07	1.73E-09	2.02E-04	4.31E-05	5.20E-04	3.29E-05	1.05E-01
Cucumber (GH heated)	Belgium	2.18E-01	8.80E-02	2.32E-05	4.72E-03	4.79E-06	1.18E-02	1.11E-04	7.83E-03	1.33E-05	4.50E-06	9.21E-06	5.63E-07	1.76E-09	2.09E-04	4.65E-05	5.16E-04	3.44E-05	1.05E-01
Green asparagus	Spain	2.15E-01	6.80E-02	1.54E-05	1.26E-02	8.57E-06	2.97E-02	7.55E-04	6.05E-03	3.68E-05	1.30E-05	2.69E-04	2.62E-06	4.70E-09	2.91E-02	3.49E-04	2.31E-04	1.63E-04	6.74E-02
Green asparagus	Greece	2.13E-01	6.78E-02	1.59E-05	1.16E-02	8.62E-06	2.93E-02	6.62E-04	6.03E-03	3.65E-05	1.20E-05	2.69E-04	2.51E-06	4.38E-09	2.90E-02	3.17E-04	2.43E-04	1.50E-04	6.70E-02
Cucumber (GH heated)	Switzerland	2.09E-01	8.48E-02	2.22E-05	4.47E-03	4.29E-06	1.09E-02	1.03E-04	7.55E-03	1.26E-05	4.30E-06	8.52E-06	5.32E-07	1.65E-09	2.04E-04	3.80E-05	4.97E-04	3.10E-05	1.00E-01
Avocado	Chile	1.98E-01	6.25E-02	1.00E-04	1.38E-02	1.04E-05	3.25E-02	5.29E-04	5.56E-03	3.71E-05	1.39E-05	3.23E-05	2.08E-06	4.73E-09	7.41E-03	2.26E-04	3.15E-04	1.26E-04	7.44E-02
Green asparagus (freight ship transport)	Peru	1.97E-01	6.16E-02	1.46E-05	9.08E-03	1.01E-05	3.30E-02	4.61E-04	5.48E-03	4.15E-05	9.89E-06	2.67E-04	2.24E-06	3.61E-09	2.89E-02	2.28E-04	2.41E-04	1.12E-04	5.75E-02
Bell pepper (GH heated)	Belgium	1.79E-01	6.99E-02	1.61E-05	7.91E-03	4.35E-06	1.21E-02	2.19E-04	6.22E-03	1.33E-05	9.20E-06	8.13E-06	9.36E-07	2.87E-09	6.11E-04	6.11E-05	3.56E-04	3.97E-05	8.10E-02
Bell pepper (GH heated)	Netherlands	1.75E-01	6.89E-02	1.61E-05	7.33E-03	4.24E-06	1.17E-02	1.70E-04	6.13E-03	1.30E-05	8.66E-06	7.91E-06	8.75E-07	2.68E-09	5.80E-04	4.25E-05	3.56E-04	3.19E-05	7.95E-02
Avocado	Peru	1.71E-01	5.42E-02	9.85E-05	1.18E-02	8.86E-06	2.86E-02	3.79E-04	4.83E-03	3.37E-05	1.20E-05	3.06E-05	1.86E-06	4.00E-09	7.32E-03	1.62E-04	2.82E-04	9.97E-05	6.33E-02
Avocado	South Africa	1.69E-01	5.39E-02	9.87E-05	1.13E-02	8.92E-06	2.83E-02	3.35E-04	4.80E-03	3.36E-05	1.16E-05	3.05E-05	1.81E-06	3.84E-09	7.29E-03	1.46E-04	2.86E-04	9.32E-05	6.28E-02
Bell pepper (GH heated)	Switzerland	1.65E-01	6.54E-02	1.50E-05	7.19E-03	3.69E-06	1.06E-02	1.73E-04	5.82E-03	1.22E-05	8.57E-06	7.16E-06	8.56E-07	2.61E-09	5.83E-04	3.75E-05	3.33E-04	3.00E-05	7.50E-02
Avocado	Mexico	1.65E-01	5.23E-02	9.83E-05	1.07E-02	8.93E-06	2.85E-02	2.91E-04	4.65E-03	3.40E-05	1.11E-05	3.01E-05	1.75E-06	3.66E-09	7.26E-03	1.27E-04	2.83E-04	8.50E-05	6.04E-02
White asparagus	France	1.63E-01	5.17E-02	9.88E-06	1.00E-02	7.62E-06	2.35E-02	6.24E-04	4.59E-03	2.58E-05	9.90E-06	4.62E-05	1.75E-06	3.60E-09	1.76E-02	2.90E-04	1.81E-04	1.33E-04	5.46E-02
White asparagus (freight ship transport)	Peru	1.48E-01	4.65E-02	9.70E-06	6.11E-03	9.31E-06	2.69E-02	2.87E-04	4.14E-03	3.06E-05	6.43E-06	4.45E-05	1.34E-06	2.39E-09	1.74E-02	1.56E-04	2.05E-04	7.61E-05	4.62E-02
White asparagus (freight ship transport)	Costa Rica	1.45E-01	4.56E-02	9.52E-06	6.05E-03	8.95E-06	2.59E-02	2.85E-04	4.06E-03	2.95E-05	6.35E-06	4.44E-05	1.33E-06	2.35E-09	1.74E-02	1.55E-04	1.98E-04	7.59E-05	4.52E-02
White asparagus	Hungary	1.39E-01	4.46E-02	9.25E-06	6.89E-03	6.84E-06	2.06E-02	3.64E-04	3.97E-03	2.37E-05	7.01E-06	4.47E-05	1.42E-06	2.53E-09	1.74E-02	1.88E-04	1.72E-04	9.05E-05	4.48E-02
White asparagus	Slovakia	1.26E-01	4.04E-02	8.48E-06	5.67E-03	6.32E-06	1.91E-02	2.71E-04	3.59E-03	2.26E-05	5.91E-06	4.38E-05	1.29E-06	2.10E-09	1.74E-02	1.49E-04	1.58E-04	7.40E-05	3.89E-02
Tomato (GH heated)	Netherlands	1.13E-01	4.46E-02	1.12E-05	3.53E-03	2.91E-06	7.39E-03	7.88E-05	3.97E-03	8.04E-06	3.84E-06	1.01E-05	4.25E-07	1.39E-09	2.35E-04	2.92E-05	2.49E-04	2.03E-05	5.25E-02
Green asparagus	Switzerland	1.12E-01	3.57E-02	9.70E-06	3.11E-03	4.56E-06	1.81E-02	3.02E-05	3.17E-03	2.84E-05	4.71E-06	2.62E-04	1.60E-06	1.39E-09	2.86E-02	4.30E-05	1.27E-04	3.55E-05	2.31E-02
Tomato (GH heated)	Belgium	1.11E-01	4.40E-02	1.10E-05	3.53E-03	2.81E-06	7.22E-03	8.15E-05	3.91E-03	7.91E-06	3.84E-06	9.98E-06	4.23E-07	1.39E-09	2.37E-04	2.89E-05	2.44E-04	2.02E-05	5.16E-02
Vine tomato (GH heated)	Netherlands	1.08E-01	4.26E-02	1.07E-05	3.38E-03	2.80E-06	7.10E-03	7.53E-05	3.79E-03	7.72E-06	3.67E-06	9.66E-06	4.06E-07	1.33E-09	2.23E-04	2.84E-05	2.37E-04	1.95E-05	5.01E-02
White asparagus	Germany	1.07E-01	3.42E-02	7.32E-06	3.98E-03	5.55E-06	1.69E-02	1.43E-04	3.04E-03	2.11E-05	4.40E-06	4.25E-05	1.11E-06	1.51E-09	1.73E-02	9.41E-05	1.37E-04	5.12E-05	3.06E-02
Vine tomato (GH heated)	Belgium	1.06E-01	4.19E-02	1.05E-05	3.38E-03	2.71E-06	6.94E-03	7.80E-05	3.73E-03	7.59E-06	3.67E-06	9.51E-06	4.05E-07	1.33E-09	2.25E-04	2.81E-05	2.33E-04	1.95E-05	4.93E-02
Tomato (GH heated)	Switzerland	1.03E-01	4.10E-02	1.01E-05	3.36E-03	2.34E-06	6.32E-03	7.98E-05	3.65E-03	7.23E-06	3.72E-06	9.34E-06	4.01E-07	1.31E-09	2.36E-04	2.31E-05	2.25E-04	1.79E-05	4.77E-02
Onion (freight ship transport)	Tasmania	9.97E-02	3.25E-02	7.13E-06	4.63E-03	8.43E-06	2.17E-02	1.04E-04	2.89E-03	2.21E-05	5.64E-06	8.73E-06	5.86E-07	1.94E-09	1.12E-03	4.23E-05	1.72E-04	2.14E-05	3.65E-02
Kiwi	New Zealand	9.89E-02	3.18E-02	5.97E-06	5.28E-03	7.69E-06	2.12E-02	1.32E-04	2.83E-03	2.24E-05	6.75E-06	5.65E-06	7.10E-07	2.17E-09	2.16E-03	4.62E-05	1.86E-04	2.25E-05	3.52E-02
Vine tomato (GH heated)	Switzerland	9.76E-02	3.90E-02	9.61E-06	3.20E-03	2.23E-06	6.04E-03	7.59E-05	3.47E-03	6.90E-06	3.54E-06	8.87E-06	3.82E-07	1.25E-09	2.24E-04	2.22E-05	2.14E-04	1.71E-05	4.53E-02
Pear	Argentina	9.17E-02	2.92E-02	6.16E-06	5.62E-03	6.28E-06	1.63E-02	2.17E-04	2.60E-03	1.58E-05	6.65E-06	7.94E-06	7.64E-07	2.20E-09	2.63E-03	8.23E-05	1.38E-04	3.70E-05	3.48E-02
Pear	New Zealand	9.13E-02	2.86E-02	6.15E-06	4.53E-03	7.53E-06	1.96E-02	1.20E-04	2.54E-03	1.97E-05	5.75E-06	7.41E-06	6.50E-07	1.91E-09	2.57E-03	4.22E-05	1.54E-04	1.95E-05	3.31E-02
Avocado	Israel	8.79E-02	2.87E-02	5.61E-06	5.35E-03	4.32E-06	1.41E-02	2.99E-04	2.55E-03	1.64E-05	5.56E-06	1.42E-05	9.28E-07	1.94E-09	7.28E-03	1.38E-04	1.29E-04	6.37E-05	2.93E-02
Apple	New Zealand	8.73E-02	2.72E-02	6.70E-06	3.76E-03	7.71E-06	1.96E-02	9.67E-05	2.42E-03	1.95E-05	4.63E-06	1.32E-05	5.53E-07	1.63E-09	2.12E-03	4.12E-05	1.56E-04	1.90E-05	3.19E-02
Onion (freight ship transport)	Peru	8.65E-02	2.96E-02	5.29E-06	4.19E-03	6.07E-06	1.66E-02	9.24E-05	2.63E-03	1.80E-05	4.45E-06	8.23E-06	5.68E-07	1.64E-09	1.14E-03	5.83E-05	1.22E-04	2.43E-05	3.20E-02
Pear	Chile	8.60E-02	2.74E-02	5.85E-06	5.00E-03	6.16E-06	1.60E-02	1.68E-04	2.44E-03	1.57E-05	6.10E-06	7.51E-06	6.97E-07	1.99E-09	2.60E-03	6.17E-05	1.34E-04	2.83E-05	3.22E-02
Apple	Argentina	8.60E-02	2.73E-02	6.64E-06	4.68E-03	6.40E-06	1.61E-02	1.79E-04	2.43E-03	1.54E-05	5.37E-06	1.36E-05	6.47E-07	1.86E-09	2.18E-03	7.56E-05	1.38E-04	3.41E-05	3.28E-02
White asparagus	Switzerland	8.32E-02	2.66E-02	5.67E-06	2.28E-03	4.52E-06	1.43E-02	2.30E-05	2.36E-03	1.92E-05	2.88E-06	4.09E-05	9.20E-07	9.06E-10	1.72E-02	3.92E-05	1.05E-04	2.84E-05	2.02E-02
Avocado	Spain	8.09E-02	2.72E-02	5.89E-06	4.26E-03	3.64E-06	1.17E-02	2.03E-04	2.42E-03	1.42E-05	4.50E-06	1.41E-05	8.16E-07	1.56E-09	7.22E-03	1.05E-04	1.31E-04	4.99E-05	2.75E-02
Apple	Chile	7.95E-02	2.52E-02	6.28E-06	3.97E-03	6.25E-06	1.57E-02	1.23E-04	2.24E-03	1.52E-05	4.74E-06	1.31E-05	5.71E-07	1.62E-09	2.14E-03	5.20E-05	1.34E-04	2.41E-05	2.99E-02
Pear	South Africa	7.94E-02	2.54E-02	5.41E-06	4.81E-03	5.43E-06	1.41E-02	1.59E-04	2.26E-03	1.39E-05	5.91E-06	7.21E-06	6.75E-07	1.89E-09	2.60E-03	5.69E-05	1.21E-04	2.66E-05	2.98E-02

Method		ReCiPe Endpoint (H) V1.05 / World ReCiPe H/A																	
Impact categorie		Sum	Climate change Human Health	Ozone depletion	Human toxicity	Photochemical oxidant formation	Particulate matter formation	Ionising radiation	Climate change Ecosystems	Terrestrial acidification	Freshwater eutrophication	Terrestrial ecotoxicity	Freshwater ecotoxicity	Marine ecotoxicity	Agricultural land occupation	Urban land occupation	Natural land transformation	Metal depletion	Fossil depletion
Unit		Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt
Citrus	South Africa	7.92E-02	2.45E-02	3.57E-05	4.46E-03	5.56E-06	1.49E-02	1.05E-04	2.18E-03	1.56E-05	4.38E-06	4.27E-05	6.18E-07	5.72E-09	2.08E-03	4.96E-05	1.43E-04	3.25E-05	3.06E-02
Eggplant (GH)	Spain	7.71E-02	2.65E-02	4.19E-06	6.67E-03	2.99E-06	1.22E-02	1.82E-04	2.36E-03	1.83E-05	8.37E-06	1.11E-05	7.88E-07	2.52E-09	6.01E-04	5.14E-05	1.02E-04	2.82E-05	2.84E-02
Apple	South Africa	7.46E-02	2.38E-02	5.92E-06	3.96E-03	5.58E-06	1.41E-02	1.29E-04	2.11E-03	1.35E-05	4.71E-06	1.29E-05	5.69E-07	1.58E-09	2.15E-03	5.32E-05	1.22E-04	2.49E-05	2.82E-02
Bell pepper (GH)	Spain	6.94E-02	2.41E-02	3.90E-06	6.04E-03	2.47E-06	7.24E-03	1.42E-04	2.14E-03	7.48E-06	4.15E-04	2.11E-03	2.63E-04	5.14E-08	5.74E-04	3.11E-05	8.05E-05	1.93E-05	2.63E-02
Grape	India	6.83E-02	2.12E-02	5.57E-06	2.50E-03	5.88E-06	1.48E-02	7.64E-05	1.89E-03	1.48E-05	2.75E-06	3.72E-06	3.15E-07	1.09E-09	2.40E-03	4.18E-05	1.27E-04	1.79E-05	2.52E-02
Grape	Chile	6.74E-02	2.10E-02	5.50E-06	2.57E-03	5.67E-06	1.43E-02	8.41E-05	1.87E-03	1.43E-05	2.81E-06	3.72E-06	3.22E-07	1.11E-09	2.40E-03	4.47E-05	1.24E-04	1.93E-05	2.50E-02
Eggplant (GH)	Netherlands	6.47E-02	2.23E-02	3.14E-06	5.96E-03	2.42E-06	1.09E-02	1.37E-04	1.99E-03	1.73E-05	7.76E-06	1.02E-05	7.09E-07	2.26E-09	5.73E-04	2.83E-05	8.11E-05	1.87E-05	2.27E-02
Grape	South Africa	6.46E-02	2.02E-02	5.23E-06	2.79E-03	5.08E-06	1.29E-02	1.08E-04	1.80E-03	1.28E-05	2.99E-06	3.67E-06	3.44E-07	1.15E-09	2.42E-03	5.33E-05	1.14E-04	2.31E-05	2.42E-02
Fennel	Spain	6.42E-02	2.31E-02	5.34E-06	2.91E-03	3.60E-06	9.53E-03	1.19E-04	2.05E-03	1.05E-05	2.62E-06	3.98E-05	3.96E-07	1.07E-09	1.32E-03	7.32E-05	1.00E-04	3.49E-05	2.50E-02
Eggplant (GH)	Belgium	6.26E-02	2.16E-02	2.91E-06	5.91E-03	2.31E-06	1.07E-02	1.36E-04	1.92E-03	1.71E-05	7.72E-06	1.00E-05	7.03E-07	2.23E-09	5.73E-04	2.66E-05	7.63E-05	1.80E-05	2.17E-02
Papaya	India	6.22E-02	2.01E-02	4.75E-06	1.78E-03	5.59E-06	1.45E-02	4.91E-05	1.79E-03	1.54E-05	1.84E-06	3.54E-06	2.52E-07	8.42E-10	1.04E-03	3.64E-05	1.22E-04	1.52E-05	2.28E-02
Banana	Peru	6.01E-02	1.97E-02	4.17E-06	2.25E-03	4.74E-06	1.31E-02	9.63E-05	1.76E-03	1.45E-05	2.22E-06	3.51E-06	3.18E-07	9.84E-10	1.35E-03	5.32E-05	1.04E-04	2.30E-05	2.16E-02
Grape	Brazil	6.01E-02	1.90E-02	5.22E-06	2.17E-03	4.90E-06	1.20E-02	5.53E-05	1.69E-03	1.20E-05	2.40E-06	3.47E-06	2.78E-07	9.33E-10	2.39E-03	3.39E-05	1.13E-04	1.50E-05	2.26E-02
Lettuce (GH)	Italy	6.00E-02	2.13E-02	3.54E-06	5.53E-03	2.29E-06	6.61E-03	1.68E-04	1.89E-03	6.53E-06	6.90E-06	3.74E-06	6.55E-07	2.00E-09	5.47E-04	4.65E-05	6.90E-05	2.45E-05	2.38E-02
Bell pepper (GH)	Netherlands	5.99E-02	2.16E-02	3.11E-06	5.93E-03	2.13E-06	6.62E-03	1.43E-04	1.92E-03	7.00E-06	7.73E-06	3.57E-06	7.06E-07	2.14E-09	5.76E-04	2.71E-05	6.42E-05	1.78E-05	2.29E-02
Citrus	Argentina	5.97E-02	1.85E-02	4.68E-06	2.03E-03	5.35E-06	1.30E-02	4.48E-05	1.64E-03	1.29E-05	1.99E-06	3.74E-05	2.77E-07	5.01E-09	2.05E-03	3.17E-05	1.16E-04	1.54E-05	2.22E-02
Onion	Spain	5.93E-02	2.12E-02	4.69E-06	4.06E-03	2.92E-06	7.68E-03	9.71E-05	1.88E-03	7.80E-06	4.92E-06	7.40E-06	5.13E-07	1.49E-09	1.12E-03	3.60E-05	8.40E-05	2.08E-05	2.31E-02
Pineapple	Ecuador	5.92E-02	1.86E-02	4.42E-06	2.32E-03	4.63E-06	1.20E-02	1.08E-04	1.65E-03	1.24E-05	2.30E-06	3.05E-05	3.84E-07	1.02E-09	1.71E-03	5.89E-05	1.05E-04	2.46E-05	2.25E-02
Banana	Ecuador	5.82E-02	1.94E-02	4.31E-06	1.88E-03	4.68E-06	1.25E-02	6.27E-05	1.72E-03	1.39E-05	1.85E-06	3.48E-06	2.79E-07	8.49E-10	1.33E-03	4.18E-05	1.05E-04	1.83E-05	2.11E-02
Lettuce (GH)	Netherlands	5.79E-02	2.08E-02	3.62E-06	5.12E-03	2.16E-06	6.13E-03	1.32E-04	1.85E-03	6.26E-06	6.52E-06	3.60E-06	6.12E-07	1.86E-09	5.25E-04	3.29E-05	7.11E-05	1.89E-05	2.32E-02
Bell pepper (GH)	Belgium	5.78E-02	2.08E-02	2.88E-06	5.88E-03	2.02E-06	6.42E-03	1.43E-04	1.85E-03	6.84E-06	7.70E-06	3.41E-06	7.01E-07	2.12E-09	5.76E-04	2.56E-05	5.95E-05	1.72E-05	2.20E-02
Citrus	Brazil	5.68E-02	1.78E-02	4.55E-06	2.08E-03	4.82E-06	1.16E-02	5.25E-05	1.58E-03	1.13E-05	2.01E-06	3.74E-05	2.82E-07	4.99E-09	2.05E-03	3.50E-05	1.09E-04	1.71E-05	2.15E-02
Melon	Brazil	5.65E-02	1.84E-02	4.84E-06	1.66E-03	4.83E-06	1.19E-02	4.57E-05	1.63E-03	1.22E-05	1.60E-06	3.49E-06	2.57E-07	8.31E-10	6.39E-04	3.57E-05	1.10E-04	1.50E-05	2.21E-02
Lettuce (GH)	Belgium	5.64E-02	2.03E-02	3.41E-06	5.13E-03	2.08E-06	6.00E-03	1.36E-04	1.80E-03	6.15E-06	6.53E-06	3.46E-06	6.12E-07	1.86E-09	5.27E-04	3.31E-05	6.67E-05	1.90E-05	2.24E-02
Papaya	Brazil	5.61E-02	1.85E-02	4.52E-06	1.58E-03	4.79E-06	1.21E-02	3.81E-05	1.65E-03	1.28E-05	1.61E-06	3.40E-06	2.30E-07	7.27E-10	1.03E-03	3.27E-05	1.10E-04	1.40E-05	2.10E-02
Eggplant (GH)	Switzerland	5.58E-02	1.91E-02	2.07E-06	5.88E-03	1.89E-06	9.93E-03	1.45E-04	1.69E-03	1.65E-05	7.72E-06	9.50E-06	6.96E-07	2.20E-09	5.79E-04	2.53E-05	5.86E-05	1.77E-05	1.83E-02
Lettuce (GH)	France	5.53E-02	1.97E-02	3.20E-06	5.20E-03	2.09E-06	6.10E-03	1.44E-04	1.75E-03	6.16E-06	6.61E-06	3.41E-06	6.19E-07	1.88E-09	5.33E-04	3.58E-05	6.25E-05	2.00E-05	2.17E-02
Kiwi	Italy	5.52E-02	1.93E-02	3.12E-06	4.69E-03	2.03E-06	6.82E-03	1.30E-04	1.72E-03	7.76E-06	6.03E-06	4.05E-06	6.33E-07	1.70E-09	2.16E-03	3.94E-05	8.93E-05	2.17E-05	2.02E-02
Carrots	Spain	5.47E-02	1.94E-02	4.59E-06	4.12E-03	2.39E-06	6.49E-03	1.13E-04	1.73E-03	6.55E-06	4.99E-06	1.04E-05	5.14E-07	1.51E-09	8.33E-04	3.93E-05	7.41E-05	2.09E-05	2.18E-02
Cucumber (GH)	Morocco	5.47E-02	1.95E-02	4.49E-06	3.22E-03	2.55E-06	6.01E-03	9.77E-05	1.73E-03	5.42E-06	3.61E-06	4.05E-06	3.81E-07	1.21E-09	2.20E-04	4.77E-05	9.11E-05	2.20E-05	2.37E-02
Broccoli	Spain	5.46E-02	2.08E-02	4.55E-06	1.81E-03	3.33E-06	8.81E-03	3.00E-05	1.85E-03	1.06E-05	1.62E-06	6.45E-06	2.35E-07	6.78E-10	9.19E-04	3.40E-05	9.11E-05	1.92E-05	2.02E-02
Vine tomato (GH)	Morocco	5.44E-02	1.94E-02	4.50E-06	3.22E-03	2.52E-06	6.00E-03	8.86E-05	1.73E-03	5.49E-06	3.67E-06	8.57E-06	3.85E-07	1.29E-09	2.39E-04	4.35E-05	9.20E-05	2.04E-05	2.36E-02
Onion	Italy	5.32E-02	1.90E-02	3.99E-06	3.94E-03	2.59E-06	7.07E-03	9.68E-05	1.69E-03	7.32E-06	4.83E-06	6.91E-06	4.97E-07	1.43E-09	1.12E-03	3.18E-05	6.98E-05	1.92E-05	2.02E-02
Tomato (GH)	Morocco	5.29E-02	1.90E-02	4.44E-06	3.02E-03	2.50E-06	5.89E-03	6.77E-05	1.69E-03	5.44E-06	3.54E-06	8.71E-06	3.66E-07	1.23E-09	2.36E-04	3.43E-05	9.15E-05	1.67E-05	2.28E-02
Citrus	Uruguay	5.24E-02	1.62E-02	4.04E-06	1.89E-03	4.61E-06	1.14E-02	4.24E-05	1.44E-03	1.14E-05	1.87E-06	3.70E-05	2.60E-07	4.93E-09	2.04E-03	2.80E-05	1.01E-04	1.41E-05	1.92E-02
Cauliflower	Spain	5.11E-02	1.93E-02	4.15E-06	1.83E-03	2.99E-06	8.01E-03	4.13E-05	1.72E-03	9.60E-06	1.69E-06	5.60E-06	2.41E-07	6.86E-10	1.01E-03	3.62E-05	8.39E-05	1.95E-05	1.90E-02
Banana	Costa Rica	5.10E-02	1.70E-02	3.69E-06	1.63E-03	4.06E-06	1.12E-02	5.02E-05	1.51E-03	1.27E-05	1.63E-06	3.02E-06	2.50E-07	7.45E-10	1.32E-03	3.41E-05	9.16E-05	1.52E-05	1.80E-02
Fennel	Italy	5.04E-02	1.84E-02	4.21E-06	2.06E-03	2.96E-06	8.04E-03	6.32E-05	1.64E-03	9.33E-06	1.88E-06	3.88E-05	3.02E-07	7.63E-10	1.28E-03	4.56E-05	7.82E-05	2.35E-05	1.87E-02
Melon	Morocco	5.03E-02	1.76E-02	4.93E-06	2.11E-03	2.45E-06	5.90E-03	8.50E-05	1.57E-03	5.82E-06	1.87E-06	3.95E-06	3.04E-07	8.87E-10	6.66E-04	5.69E-05	9.21E-05	2.46E-05	2.21E-02
Bell pepper (GH)	Switzerland	5.01E-02	1.81E-02	2.01E-06	5.76E-03	1.58E-06	5.58E-03	1.45E-04	1.61E-03	6.20E-06	7.61E-06	2.80E-06	6.84E-07	2.06E-09	5.77E-04	2.12E-05	4.12E-05	1.56E-05	1.83E-02
Strawberry	Egypt	5.01E-02	1.60E-02	3.89E-06	2.40E-03	2.91E-06	7.67E-03	1.25E-04	1.43E-03	8.00E-06	2.35E-06	1.12E-05	4.49E-07	1.07E-09	2.92E-03	6.35E-05	7.26E-05	2.80E-05	1.93E-02
Broccoli	Italy	4.96E-02	1.89E-02	3.86E-06	1.86E-03	3.02E-06	8.33E-03	4.51E-05	1.68E-03	1.02E-05	1.70E-06	6.02E-06	2.38E-07	6.82E-10	9.29E-04	3.56E-05	7.66E-05	2.00E-05	1.77E-02
Melon	Caribbean	4.92E-02	1.60E-02	1.52E-05	2.01E-03	3.64E-06	9.76E-03	3.79E-05	1.42E-03	1.07E-05	1.99E-06	4.58E-06	3.21E-07	8.68E-10	6.34E-04	2.57E-05	9.32E-05	1.47E-05	1.92E-02
Citrus	USA Florida	4.85E-02	1.52E-02	3.77E-06	2.13E-03	3.78E-06	9.32E-03	6.82E-05	1.35E-03	9.11E-06	2.05E-06	3.70E-05	2.83E-07	4.97E-09	2.06E-03	3.80E-05	8.76E-05	1.87E-05	1.82E-02
Grape	Egypt	4.78E-02	1.53E-02	3.96E-06	2.88E-03	2.79E-06	7.14E-03	1.37E-04	1.36E-03	6.77E-06	2.99E-06	3.06E-06	3.46E-07	1.06E-09	2.44E-03	6.11E-05	7.08E-05	2.73E-05	1.83E-02
Banana	Colombia	4.64E-02	1.57E-02	3.39E-06	1.46E-03	3.59E-06	1.00E-02	4.09E-05	1.39E-03	1.16E-05	1.47E-06	2.80E-06	2.31E-07	6.68E-10	1.32E-03	2.96E-05	8.30E-05	1.35E-05	1.63E-02
Lettuce (GH)	Switzerland	4.63E-02	1.68E-02	2.43E-06	4.71E-03	1.60E-06	5.01E-03	1.15E-04	1.49E-03	5.40E-06	6.18E-06	2.68E-06	5.64E-07	1.70E-09	5.14E-04	1.93E-05	4.73E-05	1.34E-05	1.76E-02
Carrots	Italy	4.63E-02	1.65E-02	3.80E-06	3.76E-03	1.98E-06	5.63E-03	9.32E-05	1.47E-03	5.89E-06	4.68E-06	9.77E-06	4.72E-07	1.37E-09	8.21E-04	2.73E-05	5.81E-05	1.60E-05	1.79E-02
Radish (GH)	Italy	4.52E-02	1.62E-02	2.78E-06	3.79E-03	1.99E-06	5.37E-03	9.33E-05	1.44E-03	5.22E-06	4.78E-06	2.74E-06	4.51E-07	1.38E-09	2.84E-04	2.53E-05	5.76E-05	1.50E-05	1.79E-02
Cauliflower	Italy	4.49E-02	1.71E-02	3.45E-06	1.69E-03	2.68E-06	7.45E-03	3.90E-05	1.52E-03	9.15E-06	1.58E-06	5.10E-06	2.23E-07	6.21E-10	1.01E-03	3.12E-05	6.99E-05	1.75E-05	1.60E-02
Strawberry	Spain	4.45E-02	1.48E-02	3.89E-06	1.88E-03	2.07E-06	5.50E-03	8.18E-05	1.32E-03	5.97E-06	1.85E-06	1.11E-05	3.70E-07	8.03E-10	2.89E-03	4.90E-05	6.90E-05	2.20E-05	1.78E-02
Pineapple	Costa Rica	4.40E-02	1.37E-02	3.45E-06	1.18E-03	3.78E-06	9.90E-03	2.43E-05	1.22E-03	1.07E-05	1.27E-06	2.96E-05	2.60E-07	6.13E-10	1.66E-03	2.23E-05	8.61E-05	9.42E-06	1.61E-02
Cauliflower	France	4.29E-02	1.63E-02	3.21E-06	1.65E-03	2.57E-06	7.24E-03	3.99E-05	1.45E-03	8.99E-06	1.56E-06	4.93E-06	2.18E-07	6.04E-10	1.01E-03	3.01E-05	6.48E-05	1.71E-05	1.50E-02
Celery root	Switzerland	4.28E-02	1.57E-02	2.80E-06	3.61E-03	1.77E-06	5.73E-03	8.28E-05	1.40E-03	6.96E-06	4.56E-06	1.78E-05	4.63E-07	2.20E-09	1.06E-03	1.97E-05	4.77E-05	1.38E-05	1.51E-02
Grape	Spain	4.16E-02	1.39E-02	3.94E-06	2.33E-03	1.93E-06	4.91E-03	8.96E-05	1.23E-03	4.69E-06	2.45E-06	2.93E-06	2.88E-07	8.57E-10	2.41E-03	4.50E-05	6.67E-05	2.07E-05	1.67E-02
Fennel	Switzerland	4.15E-02	1.55E-02	3.45E-06	1.57E-03	2.46E-06	6.93E-03	3.45E-05	1.38E-03	8.57E-06	1.45E-06	3.81E-05	2.47E-07	5.77E-10	1.27E-03	2.90E-05	6.32E-05	1.69E-05	1.46E-02
Strawberry	Greece	4.14E-02	1.34E-02	3.48E-06	1.57E-03	2.50E-06	6.44E-03	6.05E-05	1.19E-03	7.01E-06	1.59E-06	1.06E-05	3.53E-07	7.57E-10	2.88E-03	3.72E-05	6.45E-05	1.70E-05	1.58E-02
Grape	Greece	4.06E-02	1.31E-02	3.62E-06	2.22E-03	2.43E-06	6.08E-03	8.52E-05	1.17E-03	5.90E-06	2.39E-06	2.63E-06	2.75E-07	8.29E-10	2.41E-03	4.01E-05	6.39E-05	1.85E-05	1.54E-02
Onion	Switzerland	4.03E-02	1.44E-02	2.66E-06	3.54E-03	1.89E-06	5.68E-03	8.21E-05	1.28E-03	6.27E-06	4.50E-06	5.91E-06	4.49E-07	1.27E-09	1.11E-03	1.86E-05	4.24E-05	1.39E-05	1.41E-02
Broccoli	Switzerland	4.02E-02	1.57E-02	2.92E-06	1.52E-03	2.48E-06	7.23E-03	3.04E-05	1.39E-03	9.37E-06	1.42E-06	5.24E-06	1.98E-07	5.41E-10	9.20E-04	2.38E-05	5.76E-05	1.54E-05	1.33E-02

Method		ReCiPe Endpoint (H) V1.05 / World ReCiPe H/A																	
Impact categorie		Sum	Climate change Human Health	Ozone depletion	Human toxicity	Photochemical oxidant formation	Particulate matter formation	Ionising radiation	Climate change Ecosystems	Terrestrial acidification	Freshwater eutrophication	Terrestrial ecotoxicity	Freshwater ecotoxicity	Marine ecotoxicity	Agricultural land occupation	Urban land occupation	Natural land transformation	Metal depletion	Fossil depletion
Unit		Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt	Pt
Tomato (GH)	Spain	4.01E-02	1.44E-02	3.03E-06	2.72E-03	1.83E-06	4.61E-03	6.20E-05	1.28E-03	4.45E-06	3.31E-06	7.69E-06	3.27E-07	1.09E-09	2.33E-04	2.39E-05	6.26E-05	1.26E-05	1.67E-02
Cucumber (GH)	Spain	3.99E-02	1.43E-02	3.00E-06	2.67E-03	1.85E-06	4.58E-03	7.26E-05	1.27E-03	4.31E-06	3.16E-06	2.90E-06	3.16E-07	9.89E-10	2.05E-04	2.94E-05	6.12E-05	1.46E-05	1.67E-02
Zucchini	Spain	3.98E-02	1.39E-02	3.59E-06	1.12E-03	2.79E-06	6.18E-03	1.79E-05	1.24E-03	5.66E-06	9.12E-07	2.83E-06	1.62E-07	4.38E-10	9.97E-04	2.95E-05	7.59E-05	1.55E-05	1.62E-02
Iceberg lettuce (freight ship transport)	Egypt	3.96E-02	1.36E-02	3.31E-06	1.27E-03	3.03E-06	6.98E-03	3.92E-05	1.21E-03	6.85E-06	1.15E-06	2.76E-06	1.71E-07	5.13E-10	7.60E-04	3.17E-05	7.23E-05	1.48E-05	1.56E-02
Kiwi	Switzerland	3.92E-02	1.38E-02	1.65E-06	3.95E-03	1.22E-06	5.07E-03	8.86E-05	1.23E-03	6.45E-06	5.40E-06	2.85E-06	5.50E-07	1.42E-09	2.14E-03	1.52E-05	5.95E-05	1.19E-05	1.28E-02
Vine tomato (GH)	Spain	3.92E-02	1.40E-02	2.99E-06	2.61E-03	1.80E-06	4.51E-03	5.94E-05	1.25E-03	4.34E-06	3.17E-06	7.38E-06	3.15E-07	1.05E-09	2.21E-04	2.36E-05	6.18E-05	1.23E-05	1.64E-02
Pineapple	Ghana	3.89E-02	1.23E-02	3.14E-06	1.06E-03	3.16E-06	8.29E-03	2.00E-05	1.09E-03	9.01E-06	1.15E-06	2.94E-05	2.46E-07	5.44E-10	1.66E-03	2.00E-05	7.55E-05	8.68E-06	1.43E-02
Tomato (GH)	Italy	3.72E-02	1.32E-02	2.49E-06	2.93E-03	1.64E-06	4.42E-03	8.80E-05	1.17E-03	4.27E-06	3.52E-06	7.41E-06	3.47E-07	1.15E-09	2.49E-04	3.04E-05	5.11E-05	1.55E-05	1.51E-02
Strawberry	France	3.72E-02	1.23E-02	3.00E-06	1.75E-03	1.69E-06	4.80E-03	8.38E-05	1.09E-03	5.41E-06	1.76E-06	1.04E-05	3.52E-07	7.38E-10	2.89E-03	4.44E-05	5.10E-05	2.03E-05	1.41E-02
Cucumber (GH)	Italy	3.71E-02	1.31E-02	2.46E-06	2.88E-03	1.66E-06	4.39E-03	9.88E-05	1.16E-03	4.12E-06	3.38E-06	2.62E-06	3.36E-07	1.05E-09	2.21E-04	3.60E-05	4.98E-05	1.75E-05	1.52E-02
Vine tomato (GH)	Italy	3.63E-02	1.28E-02	2.45E-06	2.83E-03	1.61E-06	4.31E-03	8.55E-05	1.14E-03	4.16E-06	3.38E-06	7.10E-06	3.35E-07	1.11E-09	2.38E-04	3.02E-05	5.03E-05	1.52E-05	1.48E-02
Iceberg lettuce	Spain	3.59E-02	1.29E-02	3.36E-06	1.02E-03	2.25E-06	5.03E-03	1.73E-05	1.15E-03	4.96E-06	8.88E-07	2.78E-06	1.46E-07	4.11E-10	7.47E-04	2.54E-05	6.91E-05	1.24E-05	1.49E-02
Citrus	Spain	3.58E-02	1.18E-02	3.15E-06	1.96E-03	1.75E-06	4.19E-03	6.45E-05	1.05E-03	3.87E-06	1.81E-06	3.67E-05	2.62E-07	4.82E-09	2.06E-03	3.71E-05	6.08E-05	1.90E-05	1.44E-02
Citrus	Catania (Sicily)	3.57E-02	1.20E-02	3.34E-06	1.71E-03	1.80E-06	4.14E-03	4.03E-05	1.07E-03	3.86E-06	1.57E-06	3.67E-05	2.36E-07	4.74E-09	2.05E-03	2.91E-05	6.52E-05	1.56E-05	1.46E-02
Lettuce	Italy	3.51E-02	1.24E-02	2.93E-06	1.42E-03	2.15E-06	5.22E-03	5.22E-05	1.10E-03	5.22E-06	1.26E-06	2.39E-06	1.80E-07	5.32E-10	6.65E-04	3.69E-05	6.01E-05	1.76E-05	1.41E-02
Cauliflower	Switzerland	3.47E-02	1.36E-02	2.41E-06	1.35E-03	2.11E-06	6.29E-03	2.65E-05	1.21E-03	8.30E-06	1.31E-06	4.28E-06	1.83E-07	4.83E-10	1.01E-03	1.98E-05	4.85E-05	1.31E-05	1.12E-02
Carrots	Switzerland	3.36E-02	1.20E-02	2.48E-06	3.38E-03	1.29E-06	4.26E-03	8.06E-05	1.07E-03	4.86E-06	4.38E-06	8.79E-06	4.27E-07	1.21E-09	8.14E-04	1.49E-05	3.09E-05	1.11E-05	1.19E-02
Citrus	Israel	3.36E-02	1.05E-02	2.45E-06	2.06E-03	2.10E-06	5.46E-03	8.29E-05	9.32E-04	5.29E-06	1.97E-06	3.62E-05	2.70E-07	4.87E-09	2.07E-03	3.84E-05	5.15E-05	1.95E-05	1.24E-02
Strawberry	Italy	3.33E-02	1.11E-02	2.96E-06	1.21E-03	1.56E-06	4.31E-03	3.84E-05	9.86E-04	5.08E-06	1.27E-06	1.02E-05	3.00E-07	5.68E-10	2.87E-03	2.73E-05	5.08E-05	1.31E-05	1.27E-02
Radish (GH)	Switzerland	3.30E-02	1.19E-02	1.48E-06	3.47E-03	1.32E-06	4.06E-03	8.42E-05	1.06E-03	4.22E-06	4.53E-06	1.80E-06	4.11E-07	1.24E-09	2.79E-04	1.44E-05	3.08E-05	1.06E-05	1.21E-02
Tomato (GH)	Netherlands	3.27E-02	1.17E-02	2.21E-06	2.54E-03	1.44E-06	3.87E-03	5.88E-05	1.04E-03	3.87E-06	3.17E-06	7.10E-06	3.05E-07	1.01E-09	2.31E-04	1.79E-05	4.59E-05	1.02E-05	1.31E-02
Melon	Spain	3.26E-02	1.15E-02	3.31E-06	1.22E-03	1.66E-06	4.16E-03	3.35E-05	1.03E-03	4.49E-06	1.12E-06	2.60E-06	1.90E-07	5.12E-10	6.34E-04	2.79E-05	6.04E-05	1.27E-05	1.39E-02
Pear	Switzerland	3.24E-02	1.08E-02	1.86E-06	3.29E-03	1.08E-06	3.57E-03	8.29E-05	9.60E-04	3.88E-06	4.47E-06	4.66E-06	4.99E-07	1.19E-09	2.55E-03	1.40E-05	2.81E-05	1.00E-05	1.11E-02
Grape	Italy	3.21E-02	1.06E-02	3.09E-06	1.84E-03	1.48E-06	3.91E-03	6.02E-05	9.42E-04	3.94E-06	2.03E-06	2.22E-06	2.33E-07	6.73E-10	2.39E-03	2.90E-05	4.99E-05	1.41E-05	1.22E-02
Zucchini	France	3.20E-02	1.11E-02	2.68E-06	9.97E-04	2.37E-06	5.42E-03	2.10E-05	9.88E-04	5.06E-06	8.35E-07	2.20E-06	1.45E-07	3.77E-10	9.99E-04	2.53E-05	5.72E-05	1.39E-05	1.24E-02
Zucchini	Netherlands	3.20E-02	1.12E-02	2.77E-06	9.29E-04	2.31E-06	5.25E-03	1.37E-05	9.95E-04	4.97E-06	7.69E-07	2.23E-06	1.38E-07	3.55E-10	9.94E-04	2.31E-05	5.85E-05	1.30E-05	1.25E-02
Strawberry	Palestine	3.19E-02	1.02E-02	2.72E-06	8.94E-04	2.05E-06	5.56E-03	1.21E-05	9.07E-04	6.52E-06	1.00E-06	9.89E-06	2.86E-07	5.45E-10	2.85E-03	1.45E-05	5.16E-05	7.51E-06	1.14E-02
Vine tomato (GH)	Netherlands	3.17E-02	1.14E-02	2.17E-06	2.44E-03	1.41E-06	3.76E-03	5.62E-05	1.01E-03	3.76E-06	3.03E-06	6.79E-06	2.93E-07	9.73E-10	2.19E-04	1.76E-05	4.50E-05	9.97E-06	1.28E-02
Cabbage for conserves	Switzerland	3.17E-02	1.16E-02	1.48E-06	3.24E-03	1.16E-06	3.93E-03	7.67E-05	1.03E-03	4.64E-06	4.24E-06	1.84E-06	3.88E-07	1.16E-09	4.44E-04	1.24E-05	2.94E-05	9.52E-06	1.12E-02
Lettuce	France	3.10E-02	1.10E-02	2.61E-06	1.15E-03	1.97E-06	4.78E-03	3.36E-05	9.81E-04	4.89E-06	1.02E-06	2.09E-06	1.51E-07	4.34E-10	6.54E-04	2.81E-05	5.40E-05	1.40E-05	1.23E-02
Cucumber (GH)	Netherlands	3.06E-02	1.10E-02	2.09E-06	2.29E-03	1.39E-06	3.62E-03	5.32E-05	9.79E-04	3.57E-06	2.84E-06	2.18E-06	2.72E-07	8.40E-10	1.93E-04	1.68E-05	4.30E-05	9.44E-06	1.24E-02
Tomato (GH)	Belgium	3.05E-02	1.10E-02	1.97E-06	2.49E-03	1.32E-06	3.65E-03	5.81E-05	9.75E-04	3.71E-06	3.14E-06	6.93E-06	2.99E-07	9.92E-10	2.31E-04	1.62E-05	4.10E-05	9.57E-06	1.21E-02
Spinach	Spain	3.00E-02	1.11E-02	2.75E-06	9.58E-04	1.62E-06	4.15E-03	2.24E-05	9.91E-04	4.75E-06	8.07E-07	2.18E-06	1.22E-07	3.75E-10	3.75E-04	2.43E-05	5.63E-05	1.14E-05	1.23E-02
Cucumber (GH)	Belgium	2.98E-02	1.07E-02	1.91E-06	2.38E-03	1.32E-06	3.56E-03	6.40E-05	9.48E-04	3.52E-06	2.94E-06	2.10E-06	2.82E-07	8.68E-10	2.00E-04	1.98E-05	3.92E-05	1.08E-05	1.19E-02
Vine tomato (GH)	Belgium	2.96E-02	1.06E-02	1.93E-06	2.39E-03	1.29E-06	3.55E-03	5.55E-05	9.45E-04	3.60E-06	3.00E-06	6.62E-06	2.86E-07	9.51E-10	2.19E-04	1.59E-05	4.02E-05	9.32E-06	1.18E-02
Red cabbage	Switzerland	2.88E-02	1.06E-02	1.65E-06	2.36E-03	1.21E-06	3.92E-03	5.47E-05	9.40E-04	4.81E-06	2.98E-06	8.92E-06	3.05E-07	1.33E-09	8.55E-04	1.37E-05	3.34E-05	9.37E-06	1.01E-02
Apple	Switzerland	2.86E-02	9.44E-03	2.43E-06	2.55E-03	1.27E-06	3.63E-03	6.17E-05	8.40E-04	3.62E-06	3.38E-06	1.04E-05	4.04E-07	9.22E-10	2.11E-03	1.39E-05	3.03E-05	9.83E-06	9.94E-03
White cabbage	Switzerland	2.81E-02	1.03E-02	1.60E-06	2.33E-03	1.17E-06	3.77E-03	5.42E-05	9.16E-04	4.61E-06	2.95E-06	8.42E-06	3.00E-07	1.29E-09	8.02E-04	1.32E-05	3.23E-05	9.02E-06	9.85E-03
Grape	France	2.72E-02	9.71E-03	2.84E-06	1.74E-03	1.36E-06	3.65E-03	5.51E-05	8.64E-04	3.74E-06	1.95E-06	2.02E-06	2.21E-07	6.34E-10	3.07E-05	2.57E-05	4.49E-05	1.27E-05	1.10E-02
Melon	Italy	2.53E-02	9.01E-03	2.56E-06	9.73E-04	1.29E-06	3.42E-03	2.35E-05	8.01E-04	3.93E-06	9.19E-07	2.03E-06	1.63E-07	4.17E-10	6.28E-04	1.98E-05	4.52E-05	9.48E-06	1.04E-02
Lettuce	Switzerland	2.35E-02	8.52E-03	1.91E-06	8.30E-04	1.53E-06	3.87E-03	1.75E-05	7.57E-04	4.25E-06	7.48E-07	1.47E-06	1.13E-07	3.06E-10	6.44E-04	1.71E-05	3.97E-05	9.60E-06	8.81E-03
Melon	France	2.32E-02	8.32E-03	2.33E-06	9.00E-04	1.18E-06	3.19E-03	2.08E-05	7.40E-04	3.75E-06	8.61E-07	1.86E-06	1.53E-07	3.82E-10	6.26E-04	1.73E-05	4.05E-05	8.51E-06	9.34E-03
Spinach	Italy	2.29E-02	8.61E-03	2.00E-06	7.25E-04	1.26E-06	3.43E-03	1.34E-05	7.66E-04	4.19E-06	6.20E-07	1.62E-06	9.41E-08	2.81E-10	3.70E-04	1.66E-05	4.13E-05	8.25E-06	8.87E-03
Zucchini	Switzerland	2.24E-02	7.71E-03	1.67E-06	7.33E-04	1.83E-06	4.36E-03	1.32E-05	6.86E-04	4.26E-06	6.29E-07	1.45E-06	1.13E-07	2.64E-10	9.94E-04	1.64E-05	3.62E-05	1.04E-05	7.86E-03
Tomato (GH)	Switzerland	2.19E-02	7.90E-03	1.05E-06	2.28E-03	8.39E-07	2.71E-03	5.32E-05	7.03E-04	2.99E-06	2.98E-06	6.27E-06	2.73E-07	9.00E-10	2.28E-04	9.06E-06	2.18E-05	6.76E-06	8.00E-03
Vine tomato (GH)	Switzerland	2.10E-02	7.57E-03	1.01E-06	2.18E-03	8.08E-07	2.61E-03	5.07E-05	6.73E-04	2.88E-06	2.84E-06	5.95E-06	2.60E-07	8.59E-10	2.16E-04	8.83E-06	2.10E-05	6.52E-06	7.68E-03
Cucumber (GH)	Switzerland	2.08E-02	7.48E-03	9.73E-07	2.13E-03	8.21E-07	2.57E-03	5.59E-05	6.65E-04	2.77E-06	2.74E-06	1.41E-06	2.51E-07	7.62E-10	1.95E-04	1.14E-05	1.97E-05	7.41E-06	7.65E-03
Iceberg lettuce	Switzerland	2.08E-02	7.55E-03	1.68E-06	6.87E-04	1.37E-06	3.39E-03	1.40E-05	6.71E-04	3.73E-06	6.41E-07	1.54E-06	1.03E-07	2.57E-10	7.45E-04	1.36E-05	3.47E-05	7.89E-06	7.67E-03
Strawberry	Switzerland	1.91E-02	6.38E-03	1.56E-06	6.21E-04	8.12E-07	2.73E-03	9.61E-06	5.67E-04	3.89E-06	7.93E-07	9.13E-06	2.14E-07	2.84E-10	2.85E-03	8.21E-06	2.24E-05	5.40E-06	5.93E-03
Spinach	Switzerland	1.10E-02	4.38E-03	7.21E-07	4.35E-04	5.99E-07	2.15E-03	7.07E-06	3.90E-04	3.22E-06	3.98E-07	6.99E-07	5.79E-08	1.53E-10	3.66E-04	6.83E-06	1.47E-05	4.40E-06	3.21E-03
Round carrots	Switzerland	9.46E-03	3.00E-03	7.04E-07	3.95E-04	5.66E-07	1.61E-03	1.25E-05	2.67E-04	1.84E-06	4.20E-07	1.75E-05	1.05E-07	1.47E-10	1.16E-03	9.06E-06	1.65E-05	4.81E-06	2.97E-03

9.2.2 WATER STRESS VS. GWP

Impacts of different categories sometimes correlate well whereas others are contradicting. When comparing GWP and Water stress impacts it is visible that both situations can happen depending on the location of production. Figure 9.1 shows the comparison of all products (weighted averages of more than 80 % of the amount of fruits and vegetables sold). Figure 9.2 shows the impacts for citrus productions in different countries to illustrate the tradeoff between a “good GWP performance” and a “bad water performance”.

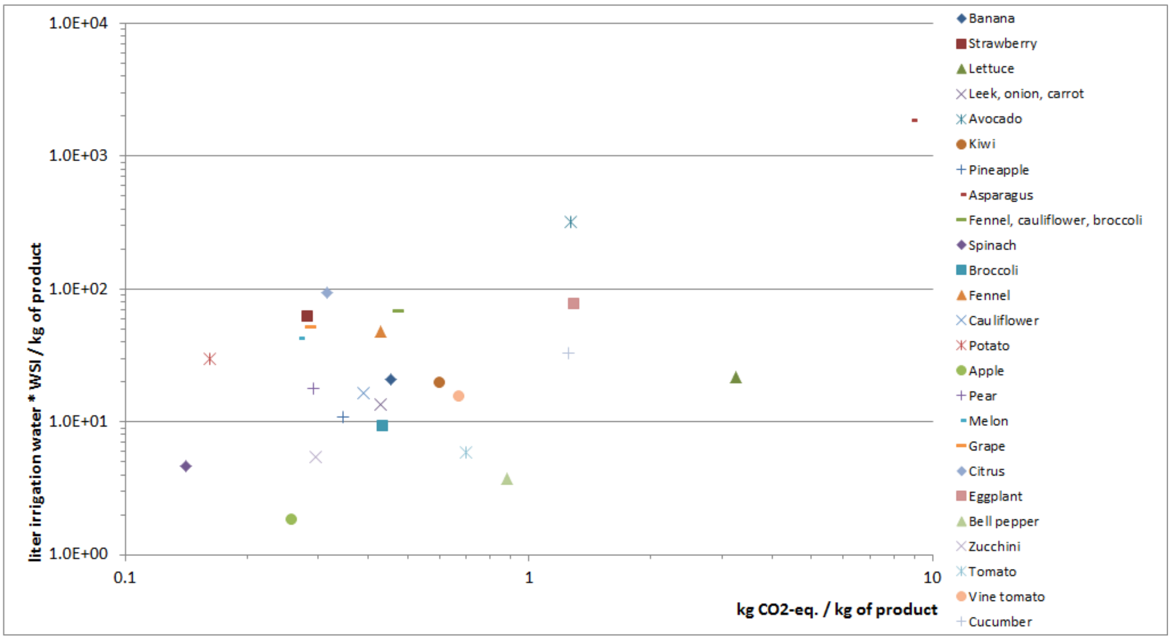

Figure 9.1 Water stress vs. GWP for different crops (weighted averages from more than 80 % of the amount of fruits and vegetables sold). Axis are scaled logarithmic.

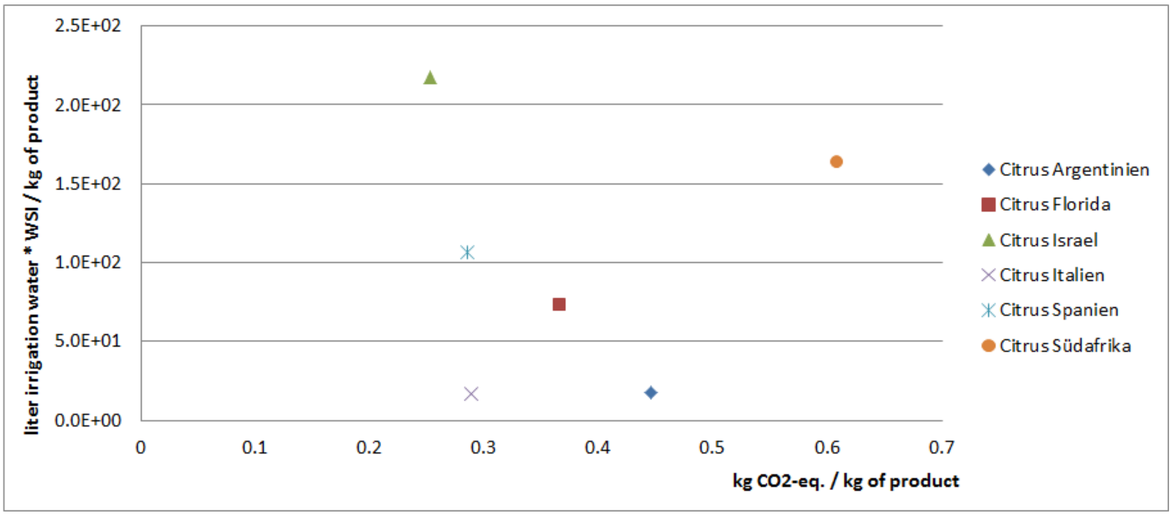

Figure 9.2 Water stress vs. GWP for citrus fruits (specific impact per kg of product from different locations).

9.3 SELECTED LCI FRUITS AND VEGETABLES FST

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
Eggplant Switzerland, greenhouse heated		1.0000E+00	kg	functional unit	
Occupation, arable	land	6.2500E-02	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	4.0000E-03	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		4.5375E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		5.3250E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		1.4850E-02	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		3.9269E-05	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		5.0000E-02	m3		(Pfister et al., 2011b)
Fertilizing, by broadcaster/CH U		1.4076E-04	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		1.4188E-02	MJ	flame treatment	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(Frischknecht et al., 2002),(Dierauer, 2000)
Electricity, low voltage, production UCTE, at grid/UCTE U		5.4167E-01	kWh	electricity use greenhouse	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		2.6625E+01	MJ	heating oil greenhouse	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Transport, lorry >32t, EURO4/RER U		2.7640E-02	tkm	seedling transport	(Google, 2009)
Electricity, low voltage, production UCTE, at grid/UCTE U		7.5000E-03	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		1.1452E-02	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	MJ	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	1.4940E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	4.2330E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	7.7138E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					

products and processes involved	sub compart - ment		unit	comments	reference
Nitrate	groundwater	8.7150E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	1.5313E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	4.3750E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
White Asparagus Switzerland		1.0000E+00	kg	functional unit	
Occupation, arable	land	2.0000E+00	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	6.8000E-02	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		2.4900E-02	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		6.0000E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		2.4000E-02	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		8.9690E-04	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		0.0000E+00	m3		(Pfister et al., 2011b)
Fertilizing, by broadcaster/CH U		8.7435E-03	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Tap water, at user/CH U		4.0000E-01	kg	water for washing	
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		0.0000E+00	MJ	flame treatment	
Electricity, low voltage, production UCTE, at grid/UCTE U		0.0000E+00	kWh	electricity use greenhouse	
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		0.0000E+00	MJ	heating oil greenhouse	
Transport, lorry >32t, EURO4/RER U		4.6988E-02	tkm	seedling transport	(Google, 2009)
Electricity, low voltage, production UCTE, at grid/UCTE U		2.2200E-03	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		1.9468E-02	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	1.4940E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
Nitrogen oxides	low. pop.	4.2330E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	4.2330E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	8.7150E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	4.9000E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	1.4000E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Cauliflower Switzerland		1.0000E+00	kg	functional unit	
Occupation, arable	land	1.1364E-01	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	4.0909E-02	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		1.0818E-02	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		1.0909E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		3.2727E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		1.2255E-04	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		2.5700E-02	m3		(Pfister et al., 2011b)
Fertilizing, by broadcaster/CH U		3.2818E-03	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		0.0000E+00	MJ	flame treatment	
Electricity, low voltage, production UCTE, at grid/UCTE U		0.0000E+00	kWh	electricity use greenhouse	
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		0.0000E+00	MJ	heating oil greenhouse	
Transport, lorry >32t, EURO4/RER U		2.8268E-01	tkm	seedling transport	(Google, 2009)
Electricity, low voltage, production UCTE, at grid/UCTE U		4.5000E-02	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		1.1712E-01	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
Emissions to air					
Ammonia	low. pop.	6.4909E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	1.8391E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	1.8391E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	3.7864E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	2.7841E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	7.9546E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Broccoli Switzerland		1.0000E+00	kg	functional unit	
Occupation, arable	land	1.0294E-01	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	5.8824E-02	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		1.2000E-02	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		1.0588E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		3.1765E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		1.5859E-04	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		3.3200E-02	m3		(Pfister et al., 2011b)
Fertilizing, by broadcaster/CH U		3.8964E-03	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		0.0000E+00	MJ	flame treatment	
Electricity, low voltage, production UCTE, at grid/UCTE U		0.0000E+00	kWh	electricity use greenhouse	
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		0.0000E+00	MJ	heating oil greenhouse	
Transport, lorry >32t, EURO4/RER U		4.0647E-01	tkm	seedling transport	(Google, 2009)
Electricity, low voltage, production UCTE, at grid/UCTE U		4.5000E-02	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		1.6841E-01	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)

products and processes involved	sub compart - ment		unit	comments	reference
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	7.2000E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	2.0400E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	2.0400E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	4.2000E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	2.5221E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	7.2059E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Cabbage for conserves Switzerland		1.0000E+00	kg	functional unit	
Occupation, arable	land	4.9020E-02	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	5.6471E-03	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		2.9294E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		7.0588E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		2.8235E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		5.9941E-05	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		7.4000E-03	m3		(Pfister et al., 2011b)
Fertilizing, by broadcaster/CH U		9.9747E-04	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		0.0000E+00	MJ	flame treatment	
Electricity, low voltage, production UCTE, at grid/UCTE U		0.0000E+00	kWh	electricity use greenhouse	
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		0.0000E+00	MJ	heating oil greenhouse	
Transport, lorry >32t, EURO4/RER U		3.9021E-02	tkm	seedling transport	(Google, 2009)
Electricity, low voltage, production UCTE, at grid/UCTE U		3.1500E-01	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t,		1.0000E-01	tkm		

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
fleet average/CH U					
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		1.6167E-02	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	1.7577E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	4.9800E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	4.9800E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	1.0253E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	1.2010E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	3.4314E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Iceberg Lettuce Switzerland		1.0000E+00	kg	functional unit	
Occupation, arable	land	8.4877E-02	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	5.3333E-02	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		3.5370E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		4.4444E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		1.3333E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		4.1148E-05	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		1.5200E-02	m3		(Pfister et al., 2011b)
Fertilizing, by broadcaster/CH U		2.0141E-03	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Tap water, at user/CH U		4.0000E-01	kg	water for washing	
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		0.0000E+00	MJ	flame treatment	
Electricity, low voltage, production UCTE, at grid/UCTE U		0.0000E+00	kWh	electricity use greenhouse	
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		0.0000E+00	MJ	heating oil greenhouse	

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
Transport, lorry >32t, EURO4/RER U		3.6853E-01	tkm	seedling transport	(Google, 2009)
Electricity, low voltage, production UCTE, at grid/UCTE U		1.5000E-02	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		1.5269E-01	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	2.1222E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	6.0130E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	6.0130E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	1.2380E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	2.0795E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	5.9414E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Fennel Switzerland		1.0000E+00	kg	functional unit	
Occupation, arable	land	1.4323E-01	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	9.6250E-02	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		9.3750E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		1.1250E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		1.0875E-02	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		2.8563E-04	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		5.0000E-02	m3		(Pfister et al., 2011b)
Fertilizing, by broadcaster/CH U		3.2705E-03	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		0.0000E+00	MJ	flame treatment	
Electricity, low voltage, production UCTE, at grid/UCTE U		0.0000E+00	kWh	electricity use greenhouse	

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		0.0000E+00	MJ	heating oil greenhouse	
Transport, lorry >32t, EURO4/RER U		6.6509E-01	tkm	seedling transport	(Google, 2009)
Electricity, low voltage, production UCTE, at grid/UCTE U		3.4500E-02	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		2.7555E-01	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	5.6250E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	1.5938E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	1.5938E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	3.2813E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	3.5091E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	1.0026E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Green Asparagus Switzerland		1.0000E+00	kg	functional unit	
Occupation, arable	land	3.3333E+00	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	1.4667E-01	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		4.1500E-02	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		1.0000E-02	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		4.0000E-02	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		2.9639E-03	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		0.0000E+00	m3		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Fertilizing, by broadcaster/CH U		5.9614E-03	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Tap water, at user/CH U		4.0000E-01	kg	water for washing	
Benzimidazole-compounds, at		4.0000E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
regional storehouse/CH U					
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		0.0000E+00	MJ	flame treatment	
Electricity, low voltage, production UCTE, at grid/UCTE U		0.0000E+00	kWh	electricity use greenhouse	
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		0.0000E+00	MJ	heating oil greenhouse	
Transport, lorry >32t, EURO4/RER U		1.0135E-01	tkm	seedling transport	(Google, 2009)
Electricity, low voltage, production UCTE, at grid/UCTE U		2.2200E-03	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		4.1989E-02	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	2.4900E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	7.0550E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	7.0550E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	1.4525E-02	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	8.1667E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	7.0000E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Cucumber Switzerland		1.0000E+00	kg	functional unit	
Occupation, arable	land	2.0417E-02	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	1.3000E-03	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		1.2000E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		3.0000E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		1.8000E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
Pesticide unspecified, at regional storehouse/CH U		7.8100E-06	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		3.0000E-02	m3		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Fertilizing, by broadcaster/CH U		7.6174E-04	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Tap water, at user/CH U		4.0000E-01	kg	water for washing	
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		4.9940E-03	MJ	flame treatment	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(Frischknecht et al., 2002),(Dierauer, 2000)
Electricity, low voltage, production UCTE, at grid/UCTE U		1.9067E-01	kWh	electricity use greenhouse	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		2.0874E+01	MJ	heating oil greenhouse	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Transport, lorry >32t, EURO4/RER U		8.9830E-03	tkm	seedling transport	(Google, 2009)
Electricity, low voltage, production UCTE, at grid/UCTE U		7.5000E-03	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		3.7218E-03	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	7.2000E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	2.0400E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	2.0400E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	4.2000E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	5.0021E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	1.4292E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Carrots Switzerland		1.0000E+00	kg	functional unit	
Occupation, arable	land	9.1667E-02	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	0.0000E+00	kg		
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		2.6100E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional		5.4000E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
storehouse/RER U					
Potassium sulphate, as K2O, at regional storehouse/RER U		4.8200E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		5.6702E-04	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		1.6000E-02	m3		(Pfister et al., 2011b)
Fertilizing, by broadcaster/CH U		1.4043E-0	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Tap water, at user/CH U		4.0000E-01	kg	water for washing	
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		0.0000E+00	MJ	flame treatment	
Electricity, low voltage, production UCTE, at grid/UCTE U		0.0000E+00	kWh	electricity use greenhouse	
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		0.0000E+00	MJ	heating oil greenhouse	
Electricity, low voltage, production UCTE, at grid/UCTE U		3.1500E-01	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	1.5660E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	4.4370E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	4.4370E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	9.1350E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	2.2458E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	6.4167E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Celery root Switzerland		1.0000E+00	kg	functional unit	
Occupation, arable	land	1.1979E-01	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	4.0000E-02	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		5.5220E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional		1.2274E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
storehouse/RER U					
Potassium sulphate, as K2O, at regional storehouse/RER U		6.6000E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		3.5159E-04	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		1.5000E-02	m3		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Fertilizing, by broadcaster/CH U		1.7056E-03	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Tap water, at user/CH U		4.0000E-01	kg	water for washing	
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		0.0000E+00	MJ	flame treatment	
Electricity, low voltage, production UCTE, at grid/UCTE U		0.0000E+00	kWh	electricity use greenhouse	
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		0.0000E+00	MJ	heating oil greenhouse	
Transport, lorry >32t, EURO4/RER U		2.7640E-01	tkm	seedling transport	(Google, 2009)
Electricity, low voltage, production UCTE, at grid/UCTE U		3.1500E-01	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		1.1452E-01	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	3.3132E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	9.3874E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	9.3874E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	1.9327E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	2.9349E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	8.3854E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Lettuce Switzerland, open land production		1.0000E+00	kg	functional unit	
Occupation, arable	land	7.2580E-02	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	6.1934E-02	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)

products and processes involved	sub compart - ment		unit	comments	reference
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		3.7160E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		6.9676E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		5.1870E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		3.8709E-05	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		2.3225E-02	m3		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Fertilizing, by broadcaster/CH U		2.1794E-03	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Tap water, at user/CH U		4.0000E-01	kg	water for washing	
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		0.0000E+00	MJ	flame treatment	
Electricity, low voltage, production UCTE, at grid/UCTE U		0.0000E+00	kWh	electricity use greenhouse	
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		0.0000E+00	MJ	heating oil greenhouse	
Transport, lorry >32t, EURO4/RER U		4.2796E-01	tkm	seedling transport	(Google, 2009)
Electricity, low voltage, production UCTE, at grid/UCTE U		1.5000E-02	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		1.7731E-01	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	2.2296E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	6.3173E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	6.3173E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	1.3006E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	1.7782E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	5.0806E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
Lettuce Switzerland, greenhouse heated		1.0000E+00	kg	functional unit	
Occupation, arable	land	5.6407E-02	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	6.3707E-02	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		1.5728E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		4.5789E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		2.3492E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		6.3747E-05	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		1.5927E-02	m3		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Fertilizing, by broadcaster/CH U		7.9122E-04	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Tap water, at user/CH U		4.0000E-01	kg	water for washing	
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		1.1750E-02	MJ	flame treatment	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(Frischknecht et al., 2002),(Dierauer, 2000)
Electricity, low voltage, production UCTE, at grid/UCTE U		4.4860E-01	kWh	electricity use greenhouse	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		4.3253E+01	MJ	heating oil greenhouse	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Transport, lorry >32t, EURO4/RER U		4.4022E-01	tkm	seedling transport	(Google, 2009)
Electricity, low voltage, production UCTE, at grid/UCTE U		1.5000E-02	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		1.8239E-01	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	9.4366E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	2.6737E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	2.6737E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	5.5047E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
Phosphorus	river	1.3820E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	3.9485E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Red Cabbage Switzerland		1.0000E+00	kg	functional unit	
Occupation, arable	land	9.7222E-02	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	2.4444E-02	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		4.0207E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		1.1111E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		4.4444E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		9.8389E-05	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		1.4000E-02	m3		(Pfister et al., 2011b)
Fertilizing, by broadcaster/CH U		1.1040E-03	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		0.0000E+00	MJ	flame treatment	
Electricity, low voltage, production UCTE, at grid/UCTE U		0.0000E+00	kWh	electricity use greenhouse	
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		0.0000E+00	MJ	heating oil greenhouse	
Transport, lorry >32t, EURO4/RER U		1.6891E-01	tkm	seedling transport	(Google, 2009)
Electricity, low voltage, production UCTE, at grid/UCTE U		2.0250E-01	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		6.9982E-02	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	2.4124E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	6.8352E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	6.8352E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)

products and processes involved	**sub compartment**		**unit**	**comments**	**reference**
Emissions to water					
Nitrate	groundwater	1.4072E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	2.3819E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	6.8056E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
White Cabbage Switzerland		1.0000E+00	kg	functional unit	
Occupation, arable	land	9.1146E-02	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	2.5000E-02	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		3.7694E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		1.0417E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		4.1667E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		9.2240E-05	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		1.3100E-02	m3		(Pfister et al., 2011b)
Fertilizing, by broadcaster/CH U		9.9357E-04	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		0.0000E+00	MJ	flame treatment	
Electricity, low voltage, production UCTE, at grid/UCTE U		0.0000E+00	kWh	electricity use greenhouse	
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		0.0000E+00	MJ	heating oil greenhouse	
Transport, lorry >32t, EURO4/RER U		1.7275E-01	tkm	seedling transport	(Google, 2009)
Electricity, low voltage, production UCTE, at grid/UCTE U		2.0250E-01	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		7.1573E-02	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	2.2617E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	6.4080E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural

products and processes involved	sub compart - ment		unit	comments	reference
					means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	6.4080E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	1.3193E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	2.2331E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	6.3802E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Round carrots Switzerland		1.0000E+00	kg	functional unit	
Occupation, arable	land	1.3333E-01	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	0.0000E+00	kg		
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		1.6200E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		1.3200E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		3.9600E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		7.6000E-05	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		3.2000E-02	m3		(Pfister et al., 2011b)
Fertilizing, by broadcaster/CH U		7.1537E-04	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Tap water, at user/CH U		4.0000E-01	kg	water for washing	
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		0.0000E+00	MJ	flame treatment	
Electricity, low voltage, production UCTE, at grid/UCTE U		0.0000E+00	kWh	electricity use greenhouse	
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		0.0000E+00	MJ	heating oil greenhouse	
Electricity, low voltage, production UCTE, at grid/UCTE U		0.0000E+00	kWh	not stored --> industry	
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	9.7200E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	2.7540E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	2.7540E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP,

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
					2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	5.6700E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	3.2667E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	9.3333E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Bell pepper Switzerland, greenhouse heated		1.0000E+00	kg	functional unit	
Occupation, arable	land	6.2500E-02	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	6.2500E-03	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		2.1000E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		8.0000E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		4.1000E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		2.0625E-07	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		3.7500E-02	m3		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Fertilizing, by broadcaster/CH U		1.0681E-03	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		1.4755E-02	MJ	flame treatment	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(Frischknecht et al., 2002),(Dierauer, 2000)
Electricity, low voltage, production UCTE, at grid/UCTE U		5.6333E-01	kWh	electricity use greenhouse	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		1.2780E+01	MJ	heating oil greenhouse	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Transport, lorry >32t, EURO4/RER U		4.3188E-02	tkm	seedling transport	(Google, 2009)
Electricity, low voltage, production UCTE, at grid/UCTE U		1.1250E-02	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		1.7893E-02	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kcal	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	1.2600E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural

products and processes involved	sub compart - ment		unit	comments	reference
					means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	3.5700E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	3.5700E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	7.3500E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	1.5313E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	4.3750E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Radish Switzerland, greenhouse heated		1.0000E+00	kg	functional unit	
Occupation, arable	land	2.9167E-02	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	0.0000E+00	kg		
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		1.3913E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		4.9689E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		1.9876E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		0.0000E+00	kg	total amount of active ingredient	
Irrigating/m3/CH U		9.9379E-03	m3		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Fertilizing, by broadcaster/CH U		1.6457E-03	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Tap water, at user/CH U		4.0000E-01	kg	water for washing	
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		8.4596E-03	MJ	flame treatment	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(Frischknecht et al., 2002),(Dierauer, 2000)
Electricity, low voltage, production UCTE, at grid/UCTE U		3.2298E-01	kWh	electricity use greenhouse	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		5.0802E+01	MJ	heating oil greenhouse	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Electricity, low voltage, production UCTE, at grid/UCTE U		1.5000E-02	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	8.3478E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
Nitrogen oxides	low. pop.	2.3652E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	3.1733E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	4.8696E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	groundwater	9.5278E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	2.7222E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Vine tomatoes Switzerland, greenhouse heated		1.0000E+00	kg	functional unit	
Occupation, arable	land	2.3386E-02	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	1.9763E-03	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		1.1660E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		6.3241E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		3.6364E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		2.6561E-05	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		2.3715E-02	m3		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Fertilizing, by broadcaster/CH U		7.0689E-04	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		5.2040E-03	MJ	flame treatment	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(Frischknecht et al., 2002),(Dierauer, 2000)
Electricity, low voltage, production UCTE, at grid/UCTE U		1.9868E-01	kWh	electricity use greenhouse	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		8.4190E+00	MJ	heating oil greenhouse	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Transport, lorry >32t, EURO4/RER U		1.3656E-02	tkm	seedling transport	(Google, 2009)
Electricity, low voltage, production UCTE, at grid/UCTE U		1.1250E-02	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		5.6579E-03	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)

products and processes involved	sub compart - ment		unit	comments	reference
Emissions to air					
Ammonia	low. pop.	6.9961E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	1.9822E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	1.9822E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	4.0810E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	5.7296E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	1.6370E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Spinach Switzerland		1.0000E+00	kg	functional unit	
Occupation, arable	land	4.1667E-02	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	0.0000E+00	kg		
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		4.4000E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		8.0000E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		6.4000E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		5.8480E-05	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		7.6000E-03	m3		(Pfister et al., 2011b)
Fertilizing, by broadcaster/CH U		5.2991E-04	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Tap water, at user/CH U		4.0000E-01	kg	water for washing	
Benzimidazole-compounds, at regional storehouse/CH U		1.0800E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		0.0000E+00	MJ	flame treatment	
Electricity, low voltage, production UCTE, at grid/UCTE U		0.0000E+00	kWh	electricity use greenhouse	
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		0.0000E+00	MJ	heating oil greenhouse	
Electricity, low voltage, production UCTE, at grid/UCTE U		7.5000E-03	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Diesel, burned in diesel-electric		7.2000E-04	kWh	cooling during	(Wild, 2008)

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
generating set/GLO U				transportation	
Emissions to air					
Ammonia	low. pop.	2.6400E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	7.4800E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	7.4800E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	1.5400E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	1.0208E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	2.9167E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Tomatoes Switzerland, greenhouse heated		1.0000E+00	kg	functional unit	
Occupation, arable	land	2.4653E-02	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	2.0833E-03	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		1.2292E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		6.6667E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		3.3333E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		2.8833E-05	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		2.5000E-02	m3		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Fertilizing, by broadcaster/CH U		7.4518E-04	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		5.4858E-03	MJ	flame treatment	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(Frischknecht et al., 2002),(Dierauer, 2000)
Electricity, low voltage, production UCTE, at grid/UCTE U		2.0944E-01	kWh	electricity use greenhouse	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		8.8750E+00	MJ	heating oil greenhouse	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Transport, lorry >32t, EURO4/RER U		1.4396E-02	tkm	seedling transport	(Google, 2009)
Electricity, low voltage, production UCTE, at grid/UCTE U		1.1250E-02	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		5.9644E-03	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	7.3750E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	2.0896E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	2.0896E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	4.3021E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	6.0399E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	1.7257E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Zucchini Switzerland		1.0000E+00	kg	functional unit	
Occupation, arable	land	1.1261E-01	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	8.6486E-03	kg		(Meienberg, 2005),(Trinnaman and Clarke, 2004),(Google, 2009),(Schilstra and Gerding, 2004)
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		3.3514E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		6.7568E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		2.7027E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		1.0811E-05	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		1.6216E-02	m3		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Fertilizing, by broadcaster/CH U		4.1354E-03	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Tap water, at user/CH U		4.0000E-01	kg	water for washing	
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		0.0000E+00	MJ	flame treatment	
Electricity, low voltage, production UCTE, at grid/UCTE U		0.0000E+00	kWh	electricity use greenhouse	
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		0.0000E+00	MJ	heating oil greenhouse	
Transport, lorry >32t, EURO4/RER U		5.9762E-02	tkm	seedling transport	(Google, 2009)

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
Electricity, low voltage, production UCTE, at grid/UCTE U		5.2500E-03	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		2.4760E-02	MJ	heating oil greenhouse for seedling production	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	2.0108E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	5.6973E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	5.6973E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	1.1730E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	2.7590E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	7.8829E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Onion Switzerland		1.0000E+00	kg	functional unit	
Occupation, arable	land	1.2500E-01	m2a		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Peat, in ground	land	0.0000E+00	kg		
Materials/fuels					
Ammonium nitrate, as N, at regional storehouse/RER U		4.1250E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Single superphosphate, as P2O5, at regional storehouse/RER U		9.0000E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Potassium sulphate, as K2O, at regional storehouse/RER U		2.7000E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011)
Pesticide unspecified, at regional storehouse/CH U		4.0158E-04	kg	total amount of active ingredient	(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Federal Office for Agriculture FOAG;, 2011)
Irrigating/m3/CH U		1.5000E-02	m3		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Fertilizing, by broadcaster/CH U		3.0304E-03	ha		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005)
Electricity/heat					
Heat, natural gas, at boiler modulating <100kW/RER U		0.0000E+00	MJ	flame treatment	
Electricity, low voltage, production UCTE, at grid/UCTE U		0.0000E+00	kWh	electricity use greenhouse	
Heat, light fuel oil, at boiler 10kW condensing, non-modulating/CH U		0.0000E+00	MJ	heating oil greenhouse	

products and processes involved	**sub compart - ment**		**unit**	**comments**	**reference**
Electricity, low voltage, production UCTE, at grid/UCTE U		3.1500E-01	kWh	storage	(Blanke and Burdick, 2005),(Konrad and Knapp, 2011),(Konrad and Willging, 2011),(George and Eghbal, 2003),(Lichtenhahn et al., 2003),(Institut für Kälte- Klima- Energietechnik (Essen), 2005)
Transport, lorry >28t, fleet average/CH U		1.0000E-01	tkm		
Diesel, burned in diesel-electric generating set/GLO U		7.2000E-04	kWh	cooling during transportation	(Wild, 2008)
Emissions to air					
Ammonia	low. pop.	2.4750E-04	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Nitrogen oxides	low. pop.	7.0125E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Dinitrogen monoxide	low. pop.	7.0125E-05	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Emissions to water					
Nitrate	groundwater	1.4438E-03	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphorus	river	3.0625E-06	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)
Phosphate	groundwater	8.7500E-07	kg		(Arbeitsgruppe Betriebswirtschaft VSGP, 2005),(FiBL, 2007),(Providers of agricultural means for production, 2011),(IFA, 2001)

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APPENDIX C

SUPPORTING INFORMATION: CLOSING DATA GAPS FOR LCA OF FOOD PRODUCTS: ESTIMATING THE ENERGY DEMAND OF FOOD PROCESSING

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10.1 METHODS

10.1.1 PHYSICOCHEMICAL PROPERTIES OF FOODS

Physicochemical properties of the raw material are necessary to estimate the energy demand in those unit operations related to heat transfer. Table 10.1 provides an overview of data for some example products.

Table 10.1 Physicochemical properties for some example food products.

Product	T (°C)	Moisture content (% wet basis)	Apparent density (kg/m³)	Freezing temperature (°C)	Specific heat (kJ/kg °C)	Latent heat kJ/kg	References
Wheat flour	20 25.2-78.3	13.2 12-13.5 11.97	710 480		1.85>T_f 1.17>T_f 1.720		(Michaidilis, Krokida et al. 2009) (Singh, Erdogdu et al. 2009) (Hayes 1987)
Cocoa powder	-	4.4	360				(Michaidilis, Krokida et al. 2009)
Coffee (instant)		- 2.5	330 330				(Michaidilis, Krokida et al. 2009) (Hayes 1987)
Coffee (ground and roasted)		- 7	330 330				
Milk powder		2-4	610				(Michaidilis, Krokida et al. 2009) (Hayes 1987)
Salt (granulated)	-	- 0.2 -	960 960		1.130-1.339		(Michaidilis, Krokida et al. 2009) (Singh, Erdogdu et al. 2009) (Hayes 1987)
Sugar (granulated)	54.7-59.1	- 0.5 13.3	800 800		1298-1256		(Michaidilis, Krokida et al. 2009) (Singh, Erdogdu et al. 2009) (Hayes 1987)
Sugar (powder)		0.5	480 480				(Michaidilis, Krokida et al. 2009) (Hayes 1987)
Milk		87.5		-0.6	3.89>T_f 2.05<T_f	288	(Hayes 1987)
Apple juice	-	87.2 87.2	1227 1051		3.85		(Michaidilis, Krokida et al. 2009) (Hayes 1987)
Orange juice	80	89.2 89	1294	-1.2	3.89>T_f		(Michaidilis, Krokida et al. 2009) (Hayes 1987)
Apple	28 20-50	85.8 87.3 84	840	-2	3.690 3.6>T_f 1.85>T_f	280-282	(Michaidilis, Krokida et al. 2009) (Singh, Erdogdu et al. 2009) (Hayes 1987)
Orange	28 -	85.9 - 87.2	768	-2.2	3661 3.77>T_f 1.93<T_f	288	(Michaidilis, Krokida et al. 2009) (Singh, Erdogdu et al. 2009) (Hayes 1987)
Vegetable					4.19		(Cleland and Valentas 1997)
Carrot	28 27-66	90 88.2	1040	-1.3	2.272 3.7>T_f 1.85<T_f	293	(Michaidilis, Krokida et al. 2009) (Singh, Erdogdu et al. 2009) (Hayes 1987)
Cauliflower		91.7	320	-	3.89>T_f	307	(Michaidilis, Krokida

Product	T (°C)	Moisture content (% wet basis)	Apparent density (kg/m³)	Freezing temperature (°C)	Specific heat (kJ/kg °C)	Latent heat kJ/kg	References
					1.97<T_f		et al. 2009) (Hayes 1987)
Green bean		90.0	384	-1.8	3.94>T_f 2.39<T_f	297	(Michaidilis, Krokida et al. 2009) (Hayes 1987)
Spinach		85-93	224	-1	3.94>T_f 2.01<T_f	307	(Michaidilis, Krokida et al. 2009) (Hayes 1987)
Potato	25 40-50	83.6 76.3-78.8 77.8	1040	-1.7	2.735-3.335 3.40>T_f 1.8<T_f	258	(Michaidilis, Krokida et al. 2009) (Singh, Erdogdu et al. 2009) (Hayes 1987)
Onion	55	81.3	1229				(Michaidilis, Krokida et al. 2009)
Green pea	60	75 74.3	1030	-1.1	3.31>T_f 1.76<T_f	247	(Michaidilis, Krokida et al. 2009) (Hayes 1987)
Beef lean	30	72	1077	-2.2	3.431 2.51>T_f 1.47<T_f	184	(Michaidilis, Krokida et al. 2009) (Singh, Erdogdu et al. 2009) (Hayes 1987)
Pork boneless	23	60-75	1090	-2	2.85 >T_f 1.6 < T_f	201	(Michaidilis, Krokida et al. 2009) (Singh, Erdogdu et al. 2009) (Hayes 1987)
Pork (lean)		57			3.054		(Singh, Erdogdu et al. 2009)
Poultry muscle	23 -	72 - 74	1100	-2.8	3.530 3.31> T_f 1.55 < T_f	247	(Michaidilis, Krokida et al. 2009) (Singh, Erdogdu et al. 2009) (Hayes 1987)
Cod			1100	-2.2	3.770 > T_f 2.050 < T_f	277	(Michaidilis, Krokida et al. 2009) (Hayes 1987)
Tuna	20 10-95	72.3 70.8 70	1071	-	3.180-3.607 3.180> T_f 1.720 < T_f	-	(Michaidilis, Krokida et al. 2009) (Singh, Erdogdu et al. 2009) (Hayes 1987)

These properties can also be calculated from composition data. The basis is to consider the food as being homogeneous but consisting of water (x_W), fat (x_F), carbohydrate (x_C), protein (x_P), and mineral fraction (x_M).

$$x_W + x_F + x_C + x_P + x_M = 1 \qquad \text{(Eq 10.1)}$$

The changes in thermal properties during freezing are dominated by the change in phase of the water component from liquid water to ice (Cleland and Valentas 1997). The aqueous component is modeled as a mixture of ice and a solution of the nonaqueous components in the liquid water which causes freezing point depression. Some of the water is loosely bound to the components (such as protein) and is never available to freeze. The total water component is thus modeled as consisting of three fractions - liquid water, ice, and bound water:

$$x_W = x_{LW} + x_I + x_B \qquad \text{(Eq 10.2)}$$

The fraction of ice can be calculated from Schwartzberg (1976):

$$x_I = (x_W - x_B)\left(1 - \frac{T_f}{T}\right) \qquad \text{(Eq 10.3)}$$

Where T is the food temperature and T_f is the freezing temperature of the food. The bound water fraction must be known to estimate x_I. It is commonly related to the solid mass fraction:

$$x_B = b x_S \qquad \text{(Eq 10.4)}$$

Some values of b can be found in the literature (Cleland and Valentas 1997). If data are not available then the use of b = 0.25 is suggested.

Density can be calculated as:

$$\frac{1}{\rho} = \sum_j \frac{x_j}{\rho_j} \qquad \text{(Eq 10.5)}$$

To estimate the specific heat (c), the most common approach is to sum up the contributions from the components. Above T_f, the model recommended is:

$$c = \sum_j x_j c_j \qquad \text{(Eq 10.6)}$$

Below T_f, effects due to phase change by the water fraction must be added. Schwartzberg (1976) developed one of the simplest models assuming that component heat capacities are constant with temperature

$$c = c_u - (x_W - x_B)\left[\frac{L' T_f}{T^2} + (c_W - c_I)\right] \qquad \text{(Eq 10.7)}$$

Where L' is the latent heat of freezing for water, L' = 334 kJ/kg.

The latent heat of freezing (L) results solely from the change in phase of water. L can be estimated from the latent heat of water and the ice fraction:

$$L = x_I \cdot L' \qquad \text{(Eq 10.8)}$$

The thermal conductivity can be calculated as a function of food volume fractions (v_j):

$$k = \sum_j v_j k_j = \rho \sum_j \frac{x_j k_j}{\rho_j} \qquad \text{(Eq 10.9)}$$

Below T_f the thermal conductivity of a food can be estimated from Cleland and Valentas (1997):

$$\frac{1}{k} = \frac{(v_{LW} + v_B)}{k_W} + \frac{(1 - v_{LW} - v_B)^2}{\sum_{j\ not\ LW,B} v_j k_j} \qquad \text{(Eq 10.10)}$$

The thermal diffusivity can be calculated as:

$$\alpha = \frac{k\rho}{c} \qquad \text{(Eq 10.11)}$$

The above equations require data for the thermal properties of the components. Although these properties do change with temperature, for the sake of simplicity average values are commonly used. Table 10.2 states typically used average values for the components of interest.

Table 10.2 Properties of pure components (Cleland and Valentas 1997)

	ρ_i (kg/m^3)	c_i J/kg K	k_i W/m K
LW, B (liquid water, bound water)	1000	4180	0.56
I (ice)	917	2110	2.22
F (fat)	930	1900	0.18
S (solids)	1450	1600	0.22
P (protein)	1380	1900	0.2
C (carbohydrates)	1550	1500	0.245
M (mineral)	2165	1100	0.26

10.1.2 INPUT DATA

Tables 10.3 and 10.4 show some data from published literature on energy consumption of unit operations.

Table 10.3 Energy consumption of unit operations for food processing.

Unit process	**Product**	**Thermal energy (MJ/kg product)**	**Electricity (MJ/kg product)**	**Data origin**
Steam peeler (Heiss 2004)	-	0.29	3.42E-03	
Steam blancher with no end seals	Spinach (Scott, Carroad et al. 1981)	2.12	4.24E-02	Measured in plant
Steam blancher hydrostatic		0.95	1.90E-02	
Steam blancher hydrostatic/ventury		0.91	1.82E-02	
Steam blancher water curtains	Grean beans (Scott, Carroad et al. 1981)	1.56	3.12E-02	
Screw conveyor blancher	Cauliflower (Rumsey, Scott et al. 1982)	0.91		Measured in plant
Tubular water blancher	Lima beans (Rumsey, Scott et al. 1982)	0.54	1.10%	
Integrated blancher-cooler	Peas (Cabinplant)	0.21-0.48	3.8E-3 – 1.04E-2	
Receiving	Spinach canning (S. Chhinnan, P. Singh et al. 1980)		2.78E-03	Measured in plant
Dry reel cleaning			3.59E-03	
Washing			4.38E-02	
Blanching		1.48	4.64E-03	
Sorting			7.26E-04	
Filling			6.60E-03	
Exhaust box		2.11	3.45E-03	
Seaming			1.01E-02	
Retorting (sterilization)		0.67	5.48E-05	
Palletizing		-	1.85E-03	
receiving station	Tomato juice (Fenco 2011)		1.05E-03	Measured in plant
Sorter			1.03E-04	
Crusher			1.39E-03	
Pump			6.69E-04	

Unit process	**Product**	**Thermal energy (MJ/kg product)**	**Electricity (MJ/kg product)**	**Data origin**
Hot break		2.37E-01	3.86E-04	
Pump			8.74E-04	
Pulper			2.43E-03	
Finisher			4.80E-04	
Pump			1.37E-04	
Screw press & conveyors			5.78E-05	
Filler/seamer			5.99E-04	
Retort		4.39E-01	1.18E-03	
Receiving station	Peeled tomato canning (Singh, Carroad et al. 1980)		1.05E-03	Measured in plant
Size grader			4.03E-05	
Roller/washer			1.18E-04	
Recirculation pump			9.08E-05	
Elevator			2.44E-05	
Lye-Bath		2.12E-01	7.05E-04	
Conveyor			1.39E-05	
Rubber-disc peeler			4.73E-04	
Elevator/conveyor			2.62E-05	
Sorter			3.93E-05	
Slicer			1.41E-04	
Conveyor			2.98E-05	
Filler			1.30E-03	
Retort		9.58E-01	1.81E-03	
Other processes	Peeled tomato canning (Heiss 2004)		0.013	
Peeling with alkaline solution			0.234	
Sterilizing		1.053		
Receiving station	Concentrated tomato (Singh, Carroad et al. 1980)		1.05E-03	Measured in plant
Sorter			7.83E-05	
Crusher			1.06E-03	
Pump			5.09E-04	
Heat Exchanger (horizontal)		1.69E-02		
Heat Exchanger (vertical)		2.32E-01		
Pulper			1.67E-03	
Finisher			3.35E-04	
Pump			8.35E-05	
Pump			4.18E-05	
Evaporator		9.85E-01	1.10E-04	
Pump			7.04E-05	
Pump			4.67E-05	
Swept surface finisher (Rotovac)		2.47E-01	6.78E-04	
Pump			2.94E-05	
Pump			7.83E-05	
Tomato concentration 5-30°Brix 1 effect	Tomato concentration (Fenco 2011)	2.01E+00	2.70E-02	
Tomato concentration 5-30°Brix 2 effects		1.21E+00	2.82E-02	

Unit process	Product	Thermal energy (MJ/kg product)	Electricity (MJ/kg product)	Data origin
Tomato concentration 5-30°Brix 3 effects		9.18E-01	2.23E-02	
Tomato concentration 5-30°Brix 4 effects		7.65E-01	1.41E-02	
Apple juice concentration 12-72°Brix 2 effects	Apple juice concentration (Fenco 2011)	3.00E-01	6.90E-01	
Apple juice concentration 12-72°Brix 3 effects		1.70E-01	3.00E-01	
Apple juice concentration 12-72°Brix 4 effects		1.60E-01	3.00E-01	
Washing, squeezing, centrifugation	Orange juice concentration (Wyss 2008)	2.86E+00		Literature data
Concentration		6.44E-01		
Pasteurization, low energy pulsed electric field		2.592		
Dilution				
Washing, squeezing, centrifugate	Direct orange juice (Wyss 2008)	2.69E+00		Literature data
Pasteurization, low energy pulsed electric field		2.592		
Thawing	Canned tuna, from frozen raw tuna (Hospido, Vazquez et al. 2006)	1.11E-1	2.41E-3	Measured in plant
Cutting			8.50E-2	
Cooking		1.39E+00	8.71E-2	
Manual cleaning of tuna			3.49E-2	
Liquid dosage and filling			1.70E-1	
Sterilization		1.94E+00	1.64E-1	
Packaging			1.20E-1	
Cutting, filling	Raw sausage (Heiss 2004)		3.6	
4 weeks ripening in controlled climate			32.4	
Solvent extraction process Extraction: pretreatment	Rapeseed -or sunflower oil (Heiss 2004)	0.075-0.095 vapor / kg seed	0.09-0.126 MJ / kg seed	
	Soybean oil (Heiss 2004)	0.1-0.12 vapor / kg seed	0.054 MJ / kg seed	
Extraction: press, extraction	Soybean oil (Heiss 2004)	0.25 kg vapor / kg seed	0.0432 MJ / kg seed	
Extraction: separation	Vegetable oil (Heiss 2004)	-	-	
Extraction: treatment of press cake		-	-	
Refining: neutralizing		-	-	
Refining: saponification		0.085-0.15 kg vapor	0.0144 – 0.0468	
Refining: bleaching		-	-	
Refining: deodorization		0.1-0.3 kg vapor	0.0072	
Reception	UHT milk (Hospido, Moreira et al. 2003)		0.89	
Pasteurization		2.844	8.9	
Sterilization		3.95	11.57	
Packaging			12.015	
Anc. activities (CIP + compressed air)		0.711	10.235	
Steam blanching	Vegetable (Heiss 2004)	9		calculated
Grinding seed to flower	Wheatflower (Heiss 2004)		0.223	
	Ryeflower (Heiss 2004)		0.266	
Wet grinding and drying	Corn starch (Heiss 2004)		5.676-7.2	
Rice milling (raw material to ready to eat rice)	Rice (Heiss 2004)		0.27	

Unit process	**Product**	**Thermal energy (MJ/kg product)**	**Electricity (MJ/kg product)**	**Data origin**
Mixing , dispersing, forming, predrying and drying (if 100 kg / h)	Pasta (Heiss 2004)	0.73	0.342-0.45	
Production of bakery products	Toast bread wheat (Heiss 2004)	5.94	1.98	
	Wheat-rye-bread (Heiss 2004)	11.34	3.78	
	Crisp bread (Heiss 2004)	44.82	14.94	
	Small wheat bakeries (Heiss 2004)	10.26	3.42	
	Yeast semi-sweet bakeries (Heiss 2004)	5.94	1.98	
	Pretzel (Heiss 2004)	17.82	5.94	
	Cracker (Heiss 2004)	10.8	3.6	
	Cookies, gingerbread (Heiss 2004)	7.56	2.52	
	Biscuit, cake (Heiss 2004)	6.48	2.16	
	Extruded bread/crouton cutter (Heiss 2004)	2.7	0.9	
Potato processing	Dried potatoes (Heiss 2004)	17-22	1.08-2.16	
	Potato flakes (Heiss 2004)	17-22	0.36-1.08	
	Potato granulate (Heiss 2004)	22-33.5	1.8-2.16	
	French fries (Heiss 2004)	25-33.5	7.2-10.8	
Production (if 2000 l/h)	Soymilk (Heiss 2004)	0.285	0.144	
Cooling during production process			0.175	
Production	Sugar from sugar beet (Heiss 2004)	7-7.5	0.828	
Cleaning, cutting, fermentation, blanching, packaging, pasteurizing (yield 70 %)	Sauerkraut (Heiss 2004)		1.154	
Cleaning, sorting, packaging, pasteurizing (yield 95 %)	Gherkin (Heiss 2004)		0.227	
Cleaning, drying, storage, soaking, germination, kiln drying, cleaning	Malt (Heiss 2004)	1.4-4	0.288-0.432	
Production (raw material = malt…)	Beer (Heiss 2004)		0.165-0.21	
Fermentation	Vinegar (Heiss 2004)		0.126-0.135	
Fetter procedure	Vinegar (Heiss 2004)		0.036	
Conventional production without pretreatment	Chocolate (Heiss 2004)		0.846-0.936	
Conventional production with pretreatment of the cacao			0.486-0.54	
Petzholdt-procedure (PIV) without pretreatment			0.306-0.36	
Petzholdt-procedure (PIV) with pretreatment			0.288-0.306	
Konticonche (depending on the recipe)			0.18-0.288	
Thouet-Conche at chocolate coating			0.162-0.234	
Thouet-Conche at chocolate			0.306-0.648	
Production (molasses, water to yeast)	Yeast fresh (Heiss 2004)	0.43	1.026	
Production (molasses, water to yeast)	Yeast dried (Heiss 2004)	2.95	7.164	
A lot of “detailed” information available	Coffee (Heiss 2004)			
Vacuum method (4 steps)	Salt from brine (Heiss 2004)	2.5	0.0612	
Thermo-compression	Salt from brine (Heiss 2004)	0.28	0.468-0.54	

Table 10.4 Energy consumption of some process units in dairies (Westergaard 2004).

	Steam **MJ/kg skim milk**	**Power** **MJ/kg skim milk**	**Fuel Oil** **MJ/kg skim milk**
5 effect evaporator + TVR, 8.5 to 48% solids	0.216	0.018	
7 effect evaporator + TVR, 8.5 to 48% solids	0.160	0.018	
1 effect evaporator + MVR /2 effect evaporator + TVR, 8.5 to 48% solids	0.05	0.048	
Spray Dry + Pneum, 48 to 96.5% solids	0.000	0.189	3.294
Spray Dry + VibroF, 48 to 96.5% solids	0.131	0.183	2.637
Spray Dry HT + VibroF, 48 to 96.5% solids	0.132	0.159	2.517
Spray Dry Ring Fluid Bed, 48 to 96.5% solids	0.189	0.140	2.079
Spray Dry Circulated Static Fluid Bed, 48 to 96.5% solids	0.200	0.120	1.789

10.1.3 BLANCHING

Convection heat losses (Q_{conv}) in a blancher can be calculated as:

$$\mathrm{Q_{conv} = A\,h\,(T_s - T_a)} \qquad \text{(Eq 10.12)}$$

Where A is the external surface of the blancher (m^2); h is the heat transfer coefficient (kJ/m^2 °C); and T_s and T_a are the temperature (°C) of the blancher surface and the surrounding air, respectively.

The radiation losses ($Qrad$) can be calculated from:

$$\mathrm{Q_{rad} = \varepsilon\,\sigma\,A\,(T_s^4 - T_w^4)} \qquad \text{(Eq 10.13)}$$

Where ε is the emissivity of the material of the blancher surface; s is the Stefan-Boltzman coefficient ($5.669 \cdot 10^{-8}$ W/m^2 K); and T_w is the temperature of the surface that surrounds the blancher.

10.1.4 EVAPORATION

Figure 10.1 shows a schematic diagram of a typical single-effect evaporator showing energy and material flows.

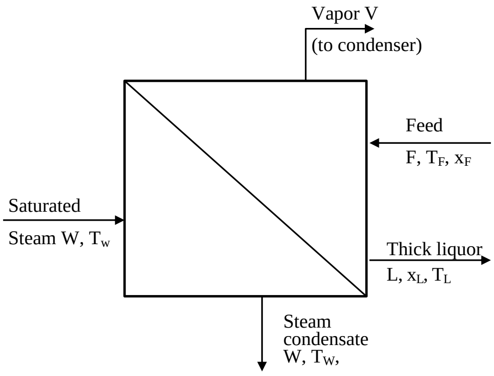

Figure 10.1 Representation of a single effect evaporator.

In order to calculate the energy consumption of a single stage evaporator first we need to know the amount of vapor released from the food that can be calculated from the total mass (Eq 10.14) and solute balance (Eq 10.4):

$$F = L + V \qquad \text{(Eq 10.14)}$$

$$FX_F = LX_L \qquad \text{(Eq 10.15)}$$

Where *F* is the flow of feed (kg/s) that is known; *L* is that of the concentrate (thick liquor); x_F and x_L are the mass fractions of solids in the feed and concentrate streams, respectively, that are data also known; and *V* is the rate of vapor flow.

The steam flow (W, kg/s) can be calculated from the energy balance, as follows:

$$Wl_w = F\, c_F\, (T_b - T_F) + Vl \qquad \text{(Eq 10.16)}$$

Where l_w (MJ/kg) is the latent heat of the steam at T_w, its condensing temperature; T_b the boiling temperature of the liquid in the evaporator; T_F the temperature of the feed; c_F the specific heat of the feed (MJ/°C/kg) and *l* (MJ/kg) the latent heat of the vapor at T_b.

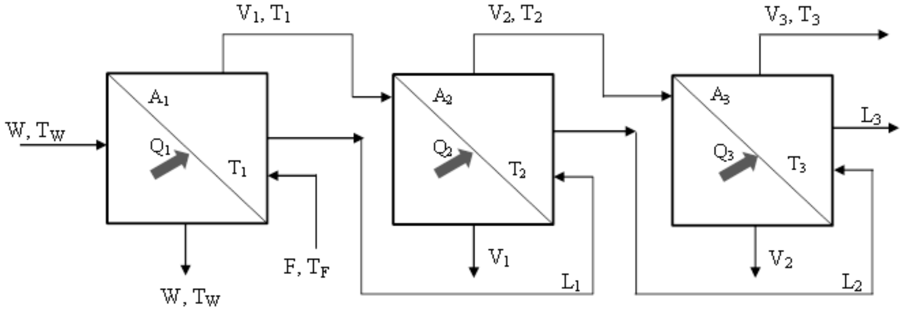

Figure 10.2 Representation of a three effect evaporator, direct circulation.

Figure 10.2 sketches a multiple evaporator with three effects and direct circulation. To calculate the steam flow for a multistage evaporator, besides the mass and the energy balances in each effect, two assumptions are made. The first one is that the area of the three stages is the same (supposing a three stages evaporator):

$$A_1 = A_2 = A_3 \qquad \text{(Eq 10.17)}$$

The second assumption (Eq 10.7) means that the heat transfer rate is the same in all the effects:

$$Q_1 = Q_2 = Q_3 \qquad \text{(Eq 10.18)}$$

$$U_1\, A_1 \Delta T_1 = U_2\, A_2 \Delta T_2 = U_3\, A_3 \Delta T_3 \qquad \text{(Eq 10.19)}$$

$$\frac{\Delta T_1}{U_1} = \frac{\Delta T_2}{U_2} = \frac{\Delta T_3}{U_3} = \frac{T_w - T_3}{U_1 + U_2 + U_3} \qquad \text{(Eq 10.20)}$$

From the last equation (Eq 10.20), the temperature differences in each evaporator stage can be computed. These ΔT are needed for the energy balances, and from the energy balances the steam flow can be computed and from it the exchange area in each stage. In case that the computed areas (A1, A2, A3) are not the same (or differ more than 5% from the average area), a new approximation of the temperature difference in an effect i ($\Delta T'_i$) is obtained from the Eq 10.21:

$$\Delta T_i' = \frac{\Delta T_i \cdot A_i}{A_{mean}} \qquad \text{(Eq 10.21)}$$

The energy balances are calculated again with the new ΔT and the calculation is repeated until the areas of each effect are sufficiently close together, that is, they differ less than 5% from the average area.

Values of *A* and *E* for different evaporator configurations are presented in Table 10.4.

Table 10.5 *A* and E (economy) coefficient values for several evaporator configurations.

Evaporator characteristics	**Product**	***A***	***E***
1-effect under vacuum (Chen and Hernandez 1997)			0.75-0.95
6-effect under vacuum (Chen and Hernandez 1997)			4.5-5.7
TASTE (Filho, Vitali et al. 1984)	Orange juice	0.85	
5-effect 8-stages TASTE (Chen 1982)	Orange juice	0.74	
Atmospheric evaporator with thermal energy recycling (Aboabboud, Horvath et al. 1996)			2.83
Single effect vacuum evaporator (Budin, Mihelić-Bogdanić et al. 1998)			0.91
2- and 3-effects (Fenco 2011)	Tomato paste		1.38-2.60
1- to 3-effects vacuum with MVR (Fellows 2000)	Skim milk concentration from 9% to 50% solids		1.67-3.33
5-effects with TVR (Westergaard 2004)			7.6
7-effects with TVR (Westergaard 2004)			10.3
1- effect with MVR or 2-effects with TVR (Westergaard 2004)			32.8

10.1.5 DEHYDRATION

Figure 10.3 shows a simplified representation of a drying process.

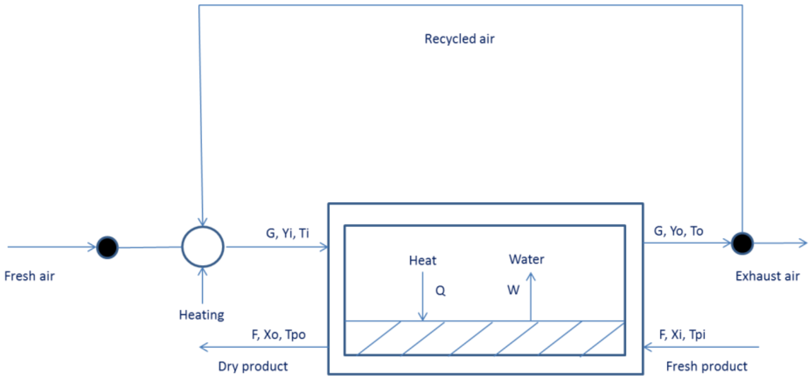

Figure 10.3 Representation of a dryer with air recycling.

Based on Figure 10.3 the mass and energy balances in a dryer are shown. Food related variables are mass flow rate F (kg dry solid/s) and water content X (kg water/kg dry solid), while drying air variables are mass flow rate G (kg dry air/s) and moisture content Y (kg vapor/kg dry air). Neglecting solid losses and leakages of air, both F and G remain constant throughout the drying process. The overall moisture balance gives the total amount of water transferred from the foodstuff to the air (W):

$$\mathrm{W} = \mathrm{F}\,(\mathrm{X_i} - \mathrm{X_o}) = \mathrm{G}(\mathrm{Y_o} - \mathrm{Y_i}) \qquad \text{(Eq 10.22)}$$

where subscripts *i* and *o* indicate inlet and outlet, respectively.

The energy balance yields:

$$\mathrm{GH_{Go}} + \mathrm{FH_{Fi}} = \mathrm{GH_{Gi}} + \mathrm{FH_{Fo}} + \mathrm{q} \qquad \text{(Eq 10.23)}$$

where q are the heat losses, and H_G and H_F the enthalpies of air and product, respectively:

$$\mathrm{H_G} = \mathrm{c_G}(\mathrm{T_G} - \mathrm{T_R}) + \mathrm{YH_L} \qquad \text{(Eq 10.24)}$$

c_G is the humid heat of the air (kJ/kg dry air °C), $c_G = 1.005 + 1.88Y$; T_G is the air temperature at the outlet or inlet, depending on the case; T_R is the reference temperature; and H_L is the vaporization heat of water (kJ/kg water).

$$\mathrm{H_F} = \mathrm{c_F}(\mathrm{T_F} - \mathrm{T_R}) + \mathrm{Xc_W}(\mathrm{T_F} - \mathrm{T_0}) \qquad \text{(Eq 10.25)}$$

where c_F is the specific heat of the product (kJ/kg °C); T_F the product temperature at the inlet or outlet; and c_W the specific heat of water.

Table 10.6 Principal types of dryers in the food industry (Berk 2009).

Dryer type	Operation	State of feed	Movement of bulk	Product examples
Cabinet	B	S	0	Fruit, vegetables, meat, fish
Tunnel	C	S	0	Fruit, vegetables
Belt	C	S, P	0	Fruit, vegetables, tomato
Belt-through	C	S	M	Vegetables
Rotary	C	S	M	Animal feed, waste
Bin	B	S	0	Vegetables
Grain dryers	B, C	S	0, M	Grain

Dryer type	Operation	State of feed	Movement of bulk	Product examples
Spray	C	S, P	M	Milk, coffee, tea
Fluid bed	B, C	S	F	Vegetables, grain, yeast
Pneumatic	C	S	M	Flour
Drum	C	L, P	0	Mashed potato, soup
Screw conveyor	C	S, P	M	Grain, waste
Mixer	B,	S	M	Particles, powders
Solar	B, C	All	All	All
Sun drying	B	S	0	Fruit, vegetables, fish

B = batch, C= continuous; S = solid, L = liquid, P = paste; 0 = static, M = moving, F= fluidized

Table 10.7 Energy efficiency and thermal energy efficiency of selected industrial dryers (Marcotte and Grabowski 2008)

Method or dryer type	Energy or thermal efficiency
Tray, batch	85
Tunnel	35-40
Spray	50
Tower	20-40
Flash	50-75
Conveyor	40-60
Fluidized bed, standard	40-80
Vibrated fluidized bed	56-80
Pulsed fluidized bed	65-80
Sheeting	50-90
Drum, indirect heating	85
Rotary, indirect heating	75-90
Rotary, direct heating	40-70
Cylinder dryer	90-92
Vacuum rotary	up to 70
Infrared	30-60
Dielectric	60
Freeze	around 10

Table 10.8 Energy consumption for selected dryers (Menon and Mujumdar 1987)

Dryer type	Typical energy consumption (kJ/kg of water evaporated)
Tunnel dryer	5500 - 6000
Band dryer	4000 - 6000
Impingement dryer	5000 - 7000
Rotary dryer	4600 - 9200
Fluid bed dryer	4000 - 6000
Flash dryer	4500 - 9000
Spray dryer	4500 - 11500
Drum dryer	3200 - 6500

Note from authors: figures are only approximate and based on current practice. Better results can often be obtained by optimizing operating conditions and using advanced technology to modify the earlier designs (Marcotte and Grabowski 2008).

Table 10.9 Typical energy consumption and heat losses for industrial dryers (Mercer 1994)

Dryer type	Typical main heat loss sources	Typical energy consumption (MJ/kg evaporated water)
Rotary		
Indirect rotary	Surface	3.0-8.0
Cascade rotary	Exhaust, leaks	3.5-12.0
Band tray and tunnel		
Cross-circulated tray/oven/band	Exhaust, surface	8.0-16.0
Cross-circulated shelf/tunnel	Exhaust, surface	6.0-16.0
Through-circulated tray/band	Exhaust	5.0-12.0
Vacuum tray/band/plate	Surface	3.5-8.0
Drum	Surface	3.0-12.0

Dryer type	Typical main heat loss sources	Typical energy consumption (MJ/kg evaporated water)
Fluidized/spouted bed	Exhaust	3.5-8.0
Spray		
Pneumatic conveying/spray	Exhaust	3.5-8.0
Two-stage	Exhaust, surface	3.3-6.0
Cylinder	Surface	3.5-10.0

10.1.6 FREEZING

Freezing time can be calculated by using Eq 4.11, shown in the main text. Table 10.10 shows the values of the constants for Eq 10.11.

Table 10.10 Values of constants for Eq 10.11 (Cleland and Valentas 1997).

Geometry	*m*	*n*	*c*	A_1	*B*
Slab[a]	1.04	0.09	0.18	-1.08125	62.9375
Slab[b]	1.03	0.10	0.16	-0.94250	62.4350
Infinite cylinder	1.00	0.09	0.17	-0.46875	28.7625
Sphere	0.90	0.06	0.18	-0.16875	15.3625

[a]Heat transfer perpendicular to fibres
[b]Heat transfer parallel to fibres

Typical contributions of the heat load components are given in Table 10.11. Once calculated the product heat load (Q_{pr}), the total heat load (Q_{tot}), and the energy consumption of the rest of components can be estimated from the percentages shown in the table.

Table 10.11 Typical component heat load percentages for well-designed freezers (Cleland and Valentas 1997)

Freezer type	Product	Fans/pumps	Pull-down	Defrost	Other
Batch air-blast	50-80%	10-40%	<10%	<5%	<5%
Continuous air-blast	50-80%	10-40%	0%	10-20%	5-10%
Plate	85-90%	5-10%	<5%	<5%	<5%
Cryogenic	85-90%	<10%	<5%	0%	<10%

10.1.7 REFRIGERATED/FROZEN STORAGE

The refrigeration requirement (or refrigeration load) of storage rooms comprise several terms: heat transfer through the insulation; air changes; introduction of goods at temperatures higher than that of the room; heat generated by respiration (fruits and vegetables); defrosting cycles; energy spent by fans, forklifts, conveyors, lighting, etc.; and people working in the room. In the following the equations to calculate each one of these terms are shown.

The heat transfer transmitted through the insulation ($Q_{transmission}$, kJ/day) is due to a temperature gradient between the outside and the inside of the chamber. This heat flow can be calculated as:

$$Q_{\mathrm{transmission}} = \mathrm{U\,A}\,(\mathrm{T_{out}} - \mathrm{T_{in}}) \qquad \text{(Eq 10.26)}$$

Where U is the global heat transfer coefficient (W/m^{2}K); A is the chamber surface; and T_{out} and T_{in} are the temperatures outside and inside (°C).

The global heat transfer coefficient is calculated as:

$$\frac{1}{\mathrm{U}} = \frac{1}{\mathrm{h_{out}}} + \sum \frac{\mathrm{e_j}}{\mathrm{k_j}} + \frac{1}{\mathrm{h_{in}}} \qquad \text{(Eq 10.27)}$$

Where h_{out} and h_{in} are the external and internal heat transfer coefficients (W m^{-2} K^{-1}); k_j is the thermal conductivity of each material of the insulating panel (W m^{-1} K^{-1}) and e_j is the thickness of each material of the insulating panel. In insulated walls the external and internal thermal resistances, $1/\mathrm{h_{out}}$ and $1/\mathrm{h_{in}}$, can be neglected since they are very low compared with the other resistances.

With respect to the factor ($\mathrm{T_{out}} - \mathrm{T_{in}}$), T_{in} is the conservation temperature inside the chamber. Nevertheless for the external temperature T_{out} it's important to take into account some factors to avoid oversizing the cooling equipment. A possibility is to calculate T_{out} as:

$$\mathrm{T_{out}} = 0.6\ \mathrm{T_{max}} + 0.4\ \mathrm{T_{mean}} \qquad \text{(Eq 10.28)}$$

$\mathrm{T_{max}}$ and $\mathrm{T_{mean}}$ are the highest and average temperature of the hottest month, respectively.

The air inside the chamber must be renewed periodically due to physiologic activity of the product. The heat transfer due to air changes ($\mathrm{Q_{air}}$, kJ/day) is computed as:

$$\mathrm{Q_{air}} = \mathrm{V}\,\rho\,\mathrm{c_{air}}\,(\mathrm{T_{air}} - \mathrm{T_{in}})\,\mathrm{N} \qquad \text{(Eq 10.29)}$$

Where V is the volume of the chamber (m^3); ρ is the air density (kg m^{-3}); c_{air} is the specific heat of the air (kJ/kg K); and N is the number of air changes per day.

The heat due to the introduction of products ($\mathrm{Q_{product}}$, kJ/day) at temperatures higher than that of the rooms calculated as:

$$\mathrm{Q_{product}} = \mathrm{M}\,\mathrm{c_{product}}\left(\mathrm{T_{product}} - \mathrm{T_{in}}\right) \qquad \text{(Eq 10.30)}$$

M is the mass of product introduced, including packaging, (kg day^{-1}); $c_{product}$ is its specific heat (kJ kg^{-1} K^{-1}); $\mathrm{T_{product}}$ is the temperature of the goods as they are brought into the chamber (°C).

When computing the refrigeration load of fruits and vegetables, it has to be taken into account that this kind of products still has vital functions, mainly respiration. Thus the heat generated by respiration (Q_{resp}) can be computed as:

$$\mathrm{Q_{resp}} = \mathrm{m\,q_r} \qquad \text{(Eq 10.31)}$$

Where m is the mass of fruit or vegetable (kg); q_r is the respiration heat (kJ/kg day). The respiration heat can be obtained from tables such as Ashrae (2009).

The energy spent by fans, conveyors and lighting ($\mathrm{Q_{others}}$) can be computed by using the following equation:

$$\mathrm{Q_{others}} = 3600(\mathrm{P\,t} + \mathrm{P'}\mathrm{t'}) \qquad \text{(Eq 10.32)}$$

P is the sum of the power of the motors of fans, conveyors, etc. (kW); t is the working time of the motors (hours/day); P' is power of lighting system (kW); t' is the working time of the lighting system (hours/day). People working in the storage chamber supposes an energy entry as sensible heat (people temperature is higher than the one in the chamber) and as latent heat (due to people respiration). Thus this heat can be calculated as:

$$Q_{\text{people}} = n\, t\, q_{\text{p}} \qquad \text{(Eq 10.33)}$$

Being *n* the number of persons working in the storage room; *t* the time they are working inside (h day^{-1}); q_p is the average estimated respiration heat of one person (627 kJ/h).

In spite of the breakdown of the heat load presented above, there are always other aspects that have not been included such as defrosting, heat from the forklifts engines, enthalpies of water condensation and solidification on the evaporator. In a simplified way, this heat together with Q_{others} and Q_{people} can be jointly estimated as 20% of Q_i.

Table 10.12 Contribution of kinds of thermal energy loads to total thermal energy load and total electric consumption (Prakash and Singh 2008).

Kind of heat load	% of heat load	% of total electric consumption
Transmission ($Q_{transmission}$)	36	19
Infiltration (doors opening)	0	0
Product ($Q_{product}$)	14	7
Electric appliances (Q_{others})	50	74

10.1.8 PASTEURIZATION

Table 10.13 Examples of heat treatment combination used in food pasteurization (Fellows 2000).

Food	Main goal	Secondary goal	Treatment conditions
Fruit juice (pH< 4.5)	Enzyme inactivation (pectinesterase, polygalacturonase)	Destruction of microorganisms causing food degradation	65°C – 30 min 77°C – 1 min 88°C – 15 s
Beer (pH< 4.5)	Microorganism destruction (wild yeasts, lactobacillus and residual yeasts)		65-68°C 20 min (bottles) 72-75°C 1-4 min 900-1000kPa
Milk (pH>4.5)	Patogen destruction (Brucella abortis, Mycobacterium tuberculosis)	Destruction of enzymes and microorganisms causing food degradation	63°C – 30 min 71,5°C – 15 s
Liquid egg (pH>4.5)	Patogen destruction (Salmonella)	Destruction of microorganisms causing food degradation	64,4°C – 2,5 min 60°C – 3,5 min
Ice cream (pH>4.5)	Patogen destruction	Destruction of microorganisms causing food degradation	65°C – 30 min 71°C – 10 min 80°C – 20 s

10.1.9 BAKING/ROASTING

Table 10.14 Comparison of specific energy consumption in baking operation (adapted from Marcotte and Grabowski (2008)).

Type of baking	**Specific energy consumption (MJ/kg)**
General (Fellows 2000)	0.45-0.6
Bread (35000 kg/day) (L.A. and W.J. 1977)	7.26
Bread (three bakeries) (Beech 1980)	6.99
Bread, bakery size (Tragardh, Solmar et al. 1980):	
250000 kg/year (batch)	13.96
3500000 kg/year (continuous)	4.88
Bread (multizone oven in USA) (Christensen and Singh 1984):	
1700 kg/h	0.86
Bread (12 bakeries in Finland) (Laukkanen 1984):	
1000000 breads/year	6.5
Bread (Bera, Mukker et al. 1991):	
USA: 35000 breads/day	7.26
India 14040 kg/day	31.82
Bread (Roosen 1993):	
9 ovens – gas fired	6.17
14 ovens - electricity	5.34

10.1.10 PUMPING

The theoretical energy needed to pump a liquid through a pipe from point 1 to point 2 is calculated from the Bernoulli equation as pump head (ΔH_{pump} in meters) by means of the following equation:

$$\Delta H_{pump} = (z_2 - z_1) + \left(\frac{v_2^2 - v_1^2}{2g}\right) + \left(\frac{P_2 - P_1}{\rho g}\right) + \Delta H_{friction} \quad \text{(Eq 10.34)}$$

Where z is the relative height (m), v is the velocity (m/s), P is the pressure (Pa), $\Delta H_{friction}$ is the pressure drop due to friction (m) and ρ is the density of the fluid (kg/m^3). The relationship between $\Delta H_{friction}$ and the Reynolds number (*Re*) is usually presented as log plots known as friction-factor charts. However, for laminar flow $\Delta H_{friction}$ can be computed as:

$$\Delta H_{friction} = \frac{64}{Re} \quad \text{(Eq 10.35)}$$

And for turbulent flow:

$$\Delta H_{friction} = \frac{2\Delta P D}{L v^2 \rho} \quad \text{(Eq 10.36)}$$

Where: *Re* is the Reynolds number, *ΔP* is the pressure drop (Pa), *D* is the diameter of the pipe (m), *L* is the length of the channel (m) and *v* is the average velocity of the fluid (m/s).

If we want to know the theoretical power needed from length units (m) as Jules:

$$W_{pump} = \Delta H_{pump} \cdot Q \quad \text{(Eq 10.37)}$$

where Q is the volumetric flow rate (m^3·s^{-1}).

The actual energy consumption of the pump (W) is calculated from its mechanical efficiency (ɳm):

$$ɳm = \frac{W_{pump}}{W} \quad \text{(Eq 10.38)}$$

10.1.11 CASE STUDY

From the composition of spinach and using the equations presented above in Chapter 10.1 of this SI, spinach physicochemical properties were estimated in Table 10.15.

Table 10.15 Physicochemical properties of spinach.

Property	**Value**	**Source**
Density ρ	951.08 kg/m^3	Eq 10.5
Specific heat unfrozen food c_u	4793.9 J/kg K	Eq 10.6
Specific heat frozen food c_f	2206.9 J/kg K	Eq 10.7
Thermal conductivity unfrozen food k_u	0.499 W/m K	Eq 10.9
Thermal conductivity frozen food k_f	0.561 W/m K	Eq 10.10
Latent heat of freezing L	$2.827 \cdot 10^5$ J/kg	Eq 10.8
Thermal diffusivity α	$1.095 \cdot 10^{-07}$	Eq 10.11

Table 10.16 Input parameters and estimated energy consumption for the case study on frozen spinach.

Unit operation	**Parameter**	**Value**	**Energy consumption (MJ/kg)**			**Equation Source**
			average	**minimum**	**maximum**	
Selection and cutting	P_N (kW)	0.92 - 1.1	$1.02\cdot10^{-3}$	$9.27\cdot10^{-4}$	$1.11\cdot10^{-3}$	Eq 10.23 (Sormac)
Washing	P_N (kW)	12 - 14	$1.31\cdot10^{-2}$	$1.21\cdot10^{-2}$	$1.41\cdot10^{-2}$	Eq 10.23 (Sormac)
Centrifuge	P_N (kW)	1.1	$1.11\cdot10^{-3}$			Eq 10.2 (Sormac)
Blanching	Steam		1.38	0.88	1.88	(Lung, Masanet et al. 2006)
Packaging*	LDPE (g/kg spinach)	10.5	n.a.			Measured
	R (m) Half thickness	0.02				Measured
Freezing in a blast freezer	t_f (h) Freezing time	11.5				Eq 10. 9
	Q_{pr}		$4.10\cdot10^{-1}$			Eq 10.11
	Q_{fan}		$1.58\cdot10^{-1}$	$5.13\cdot10^{-2}$	$3.28\cdot10^{-1}$	percentages from Table 10.11
	Q_{comp}		$3.82\cdot10^{-1}$	$3.11\cdot10^{-1}$	$4.97\cdot10^{-1}$	Eq 10.12 assuming COP 1.65
	Q_{anc}	15-20% Q_{comp}	$6.69\cdot10^{-2}$	$4.66\cdot10^{-2}$	$9.94\cdot10^{-2}$	
	Q_{fan}+Q_{comp}+ Q_{anc} Total electricity		$6.07\cdot10^{-1}$	$4.09\cdot10^{-1}$	$9.25\cdot10^{-1}$	
Frozen storage 365 days	Electricity		$8.9\cdot10^{-01}$			(Tefrile 2012)

*Due to lack of data the energy consumption of this operation was not calculated

10.2 LITERATURE

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APPENDIX D

SUPPLEMENTARY INFORMATION FOR ASSESSING THE ENVIRONMENTAL IMPACTS OF SOIL COMPACTION IN LIFE CYCLE ASSESSMENT

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11.1 DESCRIPTION OF SUPPLEMENTARY INFORMATION

This document (Appendix D) contains additional text and figures. The further supplementary information includes 4 Tables containing the inventory data for cultivation (Appendix D, Section 11.6), inventory data for machinery (Appendix D, Section 11.7), the model of (Arvidsson and Håkansson, 1991) (named TKM model) in its original and our adapted version (Appendix D, Section 11.8), and results in spreadsheet format for inventory flows and characterization factors (Appendix D, Section 11.9). Finally, the code used for all calculations and some of the output can be found on Github: https://github.com/ethz-esd/compaction_stoessel_2018.

11.2 ARVIDSSON AND HÅKANSSON (1991) VS. EXCEL MODEL OF ARVIDSSON AND HÅKANSSON

The original publication by Arvidsson and Håkansson (1991) mentions four components:

1) Effects of re-compaction after ploughing.

2) Effects of plough layer (top soil) compaction persisting after ploughing.

3) Effects of subsoil compaction.

4) Effects of traffic in ley crops.

Only components 2 and 3 are included in the Excel model. This is fine since for LCA, the persisting productivity loss is important, as it can be regarded as a resource loss (capacity to produce food and other biomass). By contrast, immediate and short-term yield decreases in the same year of management (component 1) are already considered in the functional unit, which typically addresses crop amounts, and are not included in the assessment of long-term soil productivity resource loss. Component 4 is too specific and therefore not relevant. Component 2 describes the crop response to structural damage persisting in the topsoil (0-25 cm) after ploughing and component 3 describes the crop response to subsoil compaction which causes much more persistent yield reduction than the plough layer compaction. Component 3 is split into two layers: 25-40 cm and >40 cm. The formulas for the calculation of the corrected tonne-kilometers per ha for the three soil layers are provided in the Excel model.

11.3 CHARACTERIZATION FACTORS

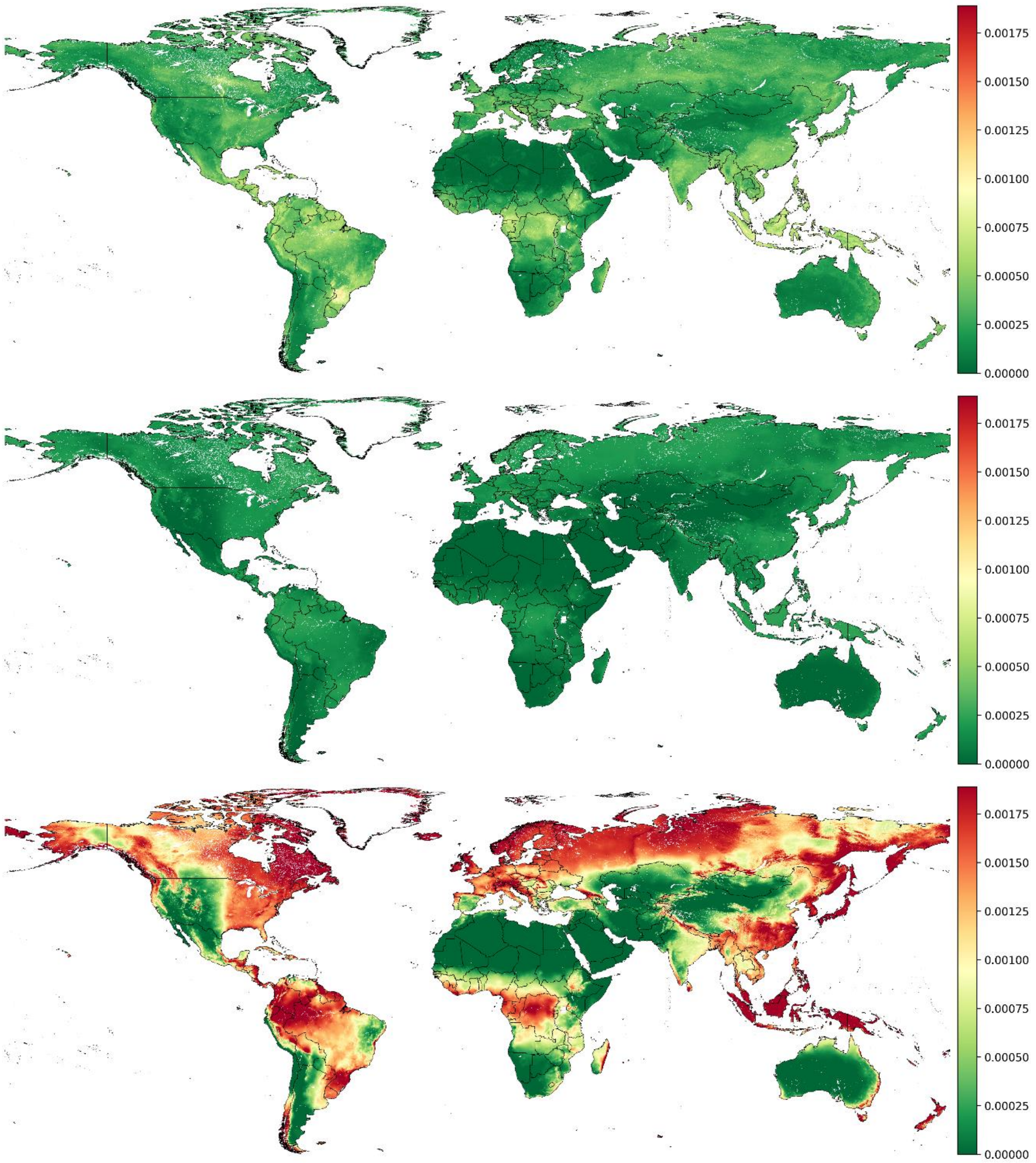


Figure 11.1 Characterization factors in the unit of average yearly yield loss (in %) over 100 years per corrected tonne-kilometer for the top soil layer (top), the mid soil layer (middle), and the bottom soil layer (bottom).

Characterization factors for countries and sub-country geo units can be found in Appendix D, Section 11.9. They have been calculated once averaging over all country/geo unit area and once averaging only over crop-area as provided in the "Cropland and Pasture Area in 2000" dataset from http://www.earthstat.org/data-download/. Averaging has been performed in Python using the "rasterstats" (version 0.12) package (https://pypi.python.org/pypi/rasterstats) and its "zonal_stats" function.

11.4 IMPACT: POTATO EXAMPLE

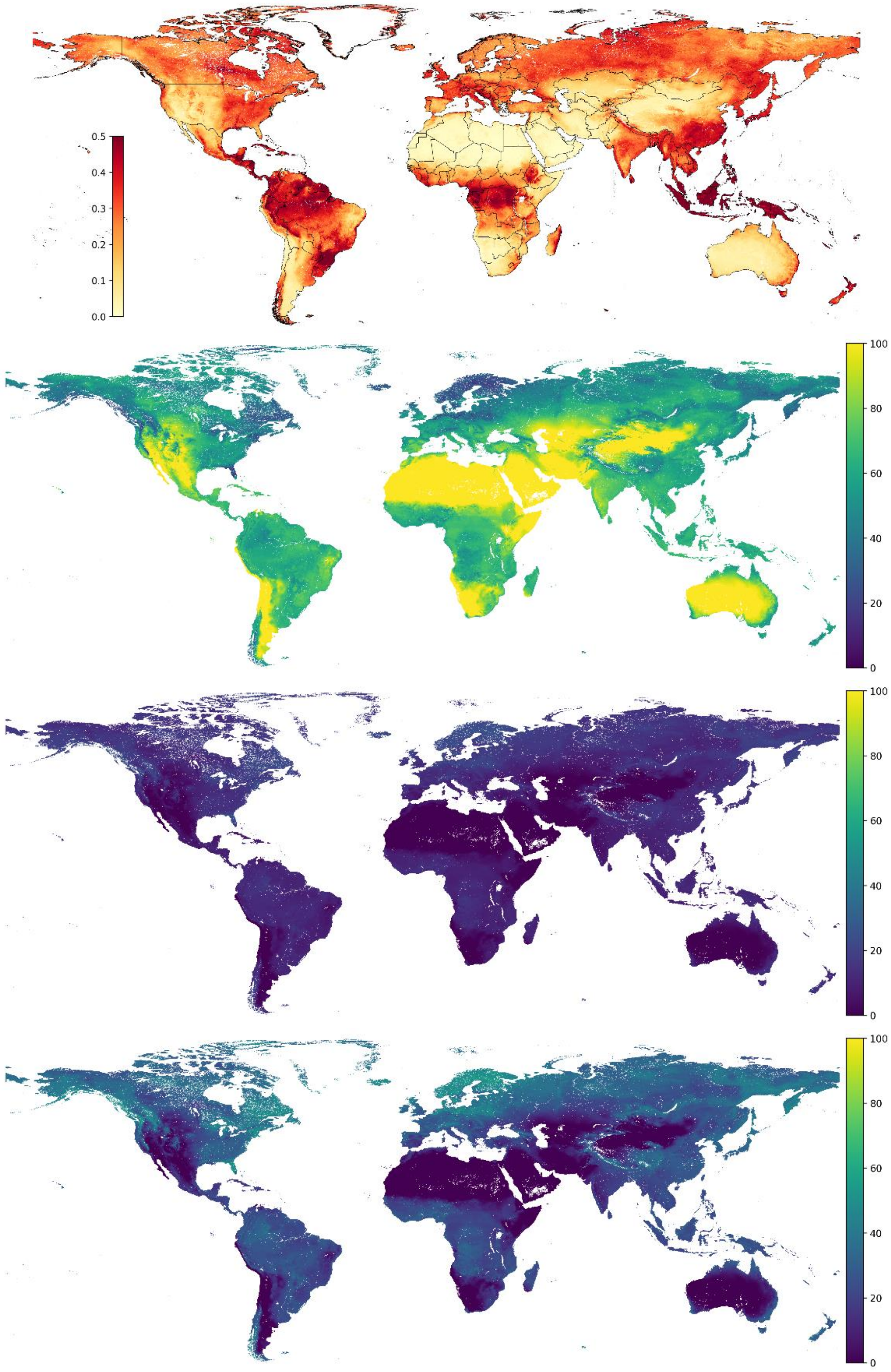


Figure 11.2 Average yearly yield loss over 100 years (in %) for potato (integrated, intensive) (top) and contribution to this impact (in %) from the top, mid, and bottom soil layers (pay attention to the different scales). The average contributions are 68% (top soil layer), 10% (mid soil layer), and 22% (bottom soil layer). If only looking at the regions where impact in the subsoil (which includes mid and bottom soil layers) actually occurs (i.e. where the

corresponding values are > 0), the average contributions are 61% (top soil layer), 12% (mid soil layer), and 26% (bottom soil layer). The maximum contribution from bottom soil is 79%.

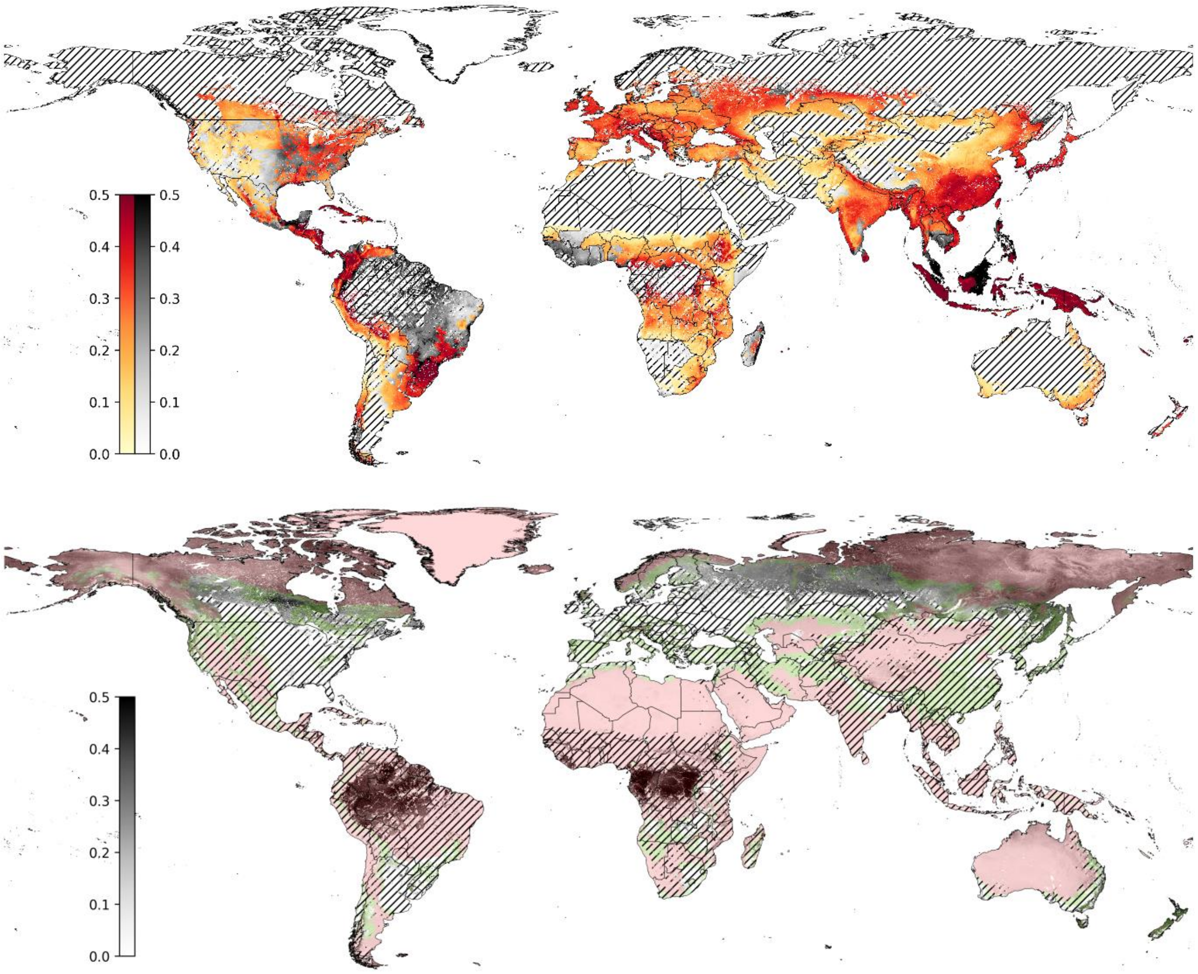


Figure 11.3 Impacts (average yearly yield loss [%] over 100 years) for potato (integrated, intensive) on crop area (top, hatched area is potential crop area) and potential crop area (bottom, hatched area is crop area);

top: potential impacts on area where potatoes are actually grown (yellow to red) and on other area used as cropland in 2000 (light to dark grey);

bottom: potential impacts on non-cropland (light to dark grey) whereby marginally suitable areas for rain-fed agriculture are shaded in green and not suitable areas are shaded in pink;

sources: http://www.earthstat.org/data-download/, “Cropland and Pasture Area in 2000” and “Harvested Area and Yield for 175 Crops” datasets; http://gaez.fao.org/Main.html, “Crop suitability index (class) for high input level rain-fed white potato” dataset: Future period 2020s, MPI ECHAM4 B2, Without CO2 fertilization (res03ehb22020hsihr0wpo_package.zip)

11.5 SUSCEPTIBILITY OF SOILS TO COMPACTION IN EUROPE

The top part of Figure 11.4 stems from the European Commission report “The state of soil in Europe” (Jones et al., 2012). The metadata describing the maps are the following: “This map shows the natural susceptibility of agricultural soils to compaction if they were to be exposed to compaction. The evaluation of the soil's natural susceptibility is based on the creation of logical connections between relevant parameters (pedotransfer rules). The input parameters for these pedotransfer rules are taken from the attributes of the European soil database, e.g. soil properties: type, texture and water regime, depth to textural change and the limitation of the soil for agricultural use. Besides the main parameters auxiliary parameters have been used as impermeable layer, depth of an obstacle to roots, water management system, dominant and secondary land use. It was assumed that every soil, as a porous medium, could be compacted"(Houšková, 2008).

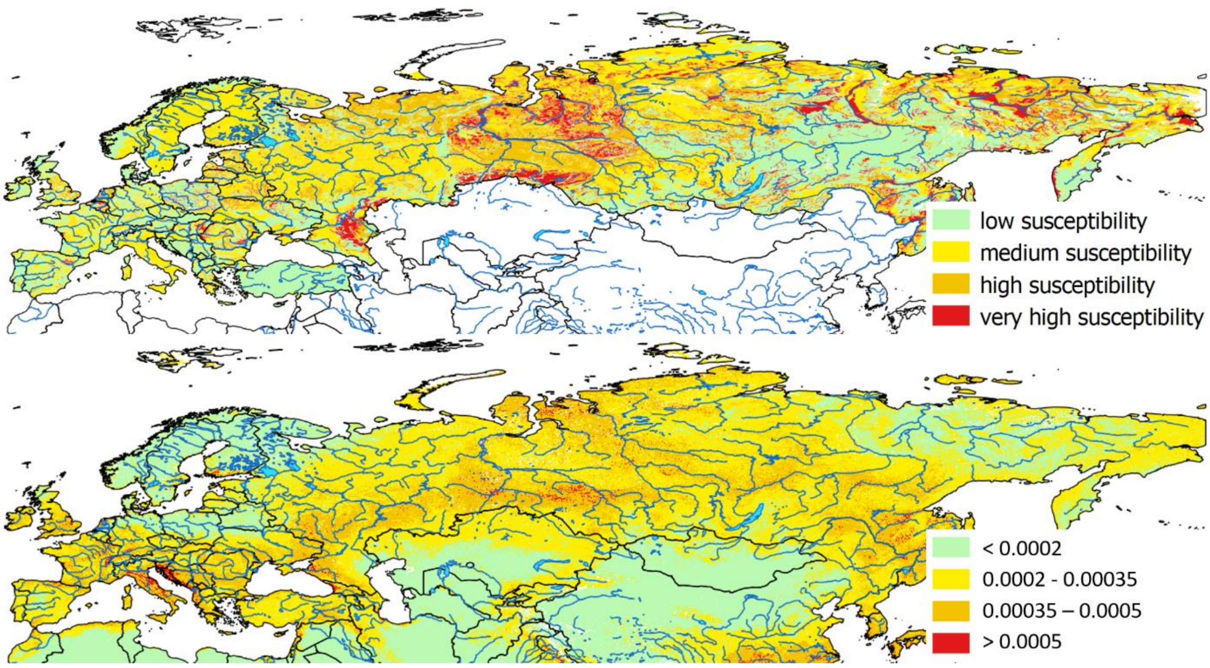


Figure 11.4 Natural susceptibility of soils to compaction (top, data from Houšková and Liedekerke (2008)): "Susceptibility is the likelihood of compaction occurring if subjected to factors that are known to cause compaction. It does not mean that a soil is compacted" (Jones et al., 2012).

Characterization factors for the top soil (in % average annual yield loss / tkm-corr) as calculated in this publication (bottom)

11.6 CROP PRODUCTION DATA

english	german	Unit	Winter wheat TOP, OeLN intensive, wholesale	Winter wheat TOP, OeLN extensive, wholesale	Winter wheat TOP, organic, wholesale	Winter wheat TOP, OeLN extensive, retail	Winter wheat TOP, organic, retail	Summer wheat TOP, OeLN intensive, wholesale	Summer wheat TOP, OeLN extensive, wholesale	Summer wheat TOP, organic, wholesale	Spelt, OeLN intensive, wholesale	Spelt, OeLN extensive, wholesale	Spelt, organic, wholesale	Spelt, OeLN extensive, retail	Spelt, organic, retail	Rye, OeLN intensive, wholesale	Rye, OeLN extensive, wholesale	Rye, organic, wholesale	Rye, OeLN extensive, retail	Rye, organic, retail	Emmer, organic, wholesale	Oat, OeLN extensive, retail	Oat, organic, retail	Triticale, OeLN intensive, wholesale	Triticale, OeLN extensive, wholesale	Triticale, organic, wholesale	Winter barley, OeLN intensive, wholesale	Winter barley, OeLN extensive, wholesale	Winter barley, organic, wholesale
10 t tandem-axle tipping trailers, hydra	10 t-Tandemkipper hydr., 2-Achs	ha	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
2-mouldboard plough	2-Schar-Pflug	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3t agricultural trailer, 2 axles	3 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-mouldboard plough	4-Schar-Pflug	ha	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5t agricultural trailer, 2 axles	5 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8t agricultural trailer, 2 axles	8 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flame weeder mounted, 3m, 4 rows	Abflammen mit Traktor, 3 m, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
chopper equipment	Abfräsen von Kraut und Strünken	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
transport off the field and conditioning	Abtransport vom Feld und Aufbereitung	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed sprayer, 500l	Anbaugebläsespritze, 500 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed sprayer, 1000l	Anhängegebläsespritze, 1000 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvestor	Ausfahren mit Schüttelroder	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tractor-mounted tree shaker	Baumschüttler, hydraulisch, 3-Punkt	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
precision seed drills, 3m	Bestellkombination, 3 m	ha	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
irrigation with tractor pump, 100m irrig	Bewässern mit Traktorpumpe, 100 m Rohr	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cultivator, 2.5m	Bodenfräse, 2.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bedformer	Dammformer für Beeren	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tractor (diverse tractor hours)	Diverse Zugkraftstunden	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hay merger, 5.5-6.5m	Doppelschwader Mitenabl 5.5-6.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seed driller, 4 rows, 3m	Einzelkornsämaschine, 4-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seed driller, 5 rows	Einzelkornsämaschine, 5-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seed driller, 6 rows, 3m	Einzelkornsämaschine, 6-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailer for 4 pallet boxes (PALOXE)	Erntewagen für 4 Grosskisten	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seedbed cultivators, 3m with roller	Federzinkenegge, 3 m mit Krümler	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, 12m	Feldspritze, 12 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, 15m	Feldspritze, 15 m	ha	3.0	2.0	0.0	2.0	0.0	3.0	2.0	0.0	3.0	2.0	0.0	2.0	0.0	3.0	2.0	0.0	2.0	0.0	0.0	2.0	0.0	3.0	2.0	0.0	3.0	2.0	0.0
mower and mower conditioner, 3m	Frontkreiselmäher + Heckaufbereiter 3m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
loader waggon, >20 m3/5 t FS	Futterernte Ladewagen, >20 m3/5 t FS	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet harvester + conveyor belt	Futterrübenernter + Überladeband	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, 200-300l	Gebläsespritze, 200-300 l, Dreipunktanbau	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed overseeder with roller, 3m	Grassämaschine mit Walze, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cultivator with roller, 3m	Grubber mit Nachläufer, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
disc spreader, 1000l	Grunddüngung, Schleuderstreuer, 1000 l	ha	1.0	1.0	0.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	0.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
disc spreader, 450l	Grunddüngung, Schleuderstreuer, 450 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
manure tanker vacuum, 4m3	Güllen, 4 m3-Vakuumfass, pro m3	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
manure tanker with row crop injector,	Güllen, Schleppschlauch 6 m3-Pumpf. ; pro m3	ha	0.0	1.0	2.0	1.0	2.0	0.0	1.0	2.0	0.0	1.0	2.0	1.0	2.0	0.0	1.0	2.0	1.0	2.0	2.0	1.0	2.0	0.0	1.0	2.0	0.0	1.0	2.0
mechanical weeding, finger weeder, 5	Hackbürste, 5-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 2 rows	Hacken/Häufeln, 2-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 3 rows	Hacken/Häufeln, 3-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 4 rows	Hacken/Häufeln, 4-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tined weeder, 6m	Hackstriegel, 6 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tined weeder, 9m, hydraulic	Hackstriegel, 9 m hydraulisch	ha	0.0	0.0	3.0	0.0	3.0	0.0	0.0	2.0	0.0	0.0	2.0	0.0	2.0	0.0	0.0	3.0	0.0	3.0	2.0	0.0	3.0	0.0	0.0	2.0	0.0	0.0	2.0
hydraulic lift, self-propelled, by electri	Hebebühne schwer, selbstfahrend, el.	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, folding arms, 400l	Herbizidfass 400 l mit Balken beidseitig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
carrot harvester	Karottenvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
row crop cultivator, 4 rows	Kartoffelhack- und häufelgerät, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato haulm topper, 4 rows	Kartoffelkrautschläger, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato planter, 4 rows	Kartoffellegeautomat, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato harvester, 1 row	Kartoffelvollernter, 1-reihig, Rollboden	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed muck spreader for orachards, 3	Kompoststreuer für Obstanlagen, 3 m3	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
disc spreader, 1000l	Kopfdüngung, Schleuderstreuer, 1000 l	ha	3.0	2.0	0.0	2.0	0.0	3.0	2.0	1.0	3.0	2.0	0.0	2.0	0.0	3.0	2.0	0.0	2.0	0.0	0.0	2.0	0.0	3.0	2.0	0.0	3.0	2.0	0.0
disc spreader, 450l	Kopfdüngung, Schleuderstreuer, 450 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet defoliator, 6 rows	Köpfroder 6-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spreader for slug pellets	Körnerstreuer (Schnecken)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
power harrow, 3m	Kreiselegge, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rakes/tedder, 6.1-7.5 m	Kreiselheuer, 6.1-7.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rotary mower, 2.1-2.6m	Kreiselmäher, 2.1-2.6 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailer for distributing empty boxes	Leeres Gebinde verteilen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvester, 150 kW (soybean, peas)	Mähdrescher, 150 kW (Soja, Erbsen)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvester, 150 kW (cereal, beans)	Mähdrescher, 150kW (Getreide, Ackerbohnen)	ha	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
harvester, 90 kW (maize, CCM)	Mähdrescher, 90 kW (Mais, CCM)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maize cultivator, 4 rows, 3m, 2 pers.	Maisscharhackgerät, 4-reihig, 3 m, 2 Pers.	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maize cultivator, 4 rows, 3m	Maissternhackgerät, 4-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed muck spreader, hydraulic, 3t	Misten, Hydrauliklader, 3 t-Zetter, pro t	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed muck spreader, hydraulic, 7t	Misten, Hydrauliklader, 7 t-Zetter, pro t	ha	0.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0
motor-mowers, 1.9m	Motormäher, 1.9 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted chopper, 2.8m	Mulchgerät mit Schwenkarm, 2.8 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cultivator, 3m	Nachbearbeitung, Grubber, 3 m	ha	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
maintenance of ecological compensati	Pflege Wildkrautstreifen (Schnitt, Erneuern)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
levelling blade for tractors	Planierschild zu Traktor	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
square baler big	Quaderballenpresse gross	ha	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
conveyor belt	Querförderband	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beetroot harvester	Randenvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
roller, 3m	Rauwalze, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rotary hoe, 5 rows 50cm	Reihenhackfräse, 5-reihig 50 cm	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
vegetable harvostor (brussel sprouts)	Rosenkohlvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet row hoe, 6 rows, 3m, 2 pers	Rübenscharhackgerät, 6-reihig, 3 m, 2 Pers.	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet row hoe, 6 rows, 3m	Rübensternhackgerät, 6-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
round baler	Rundballenpresse mittel, Netzbindung	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted seeder, 3m	Sämaschine, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flail mower, 2-2.5m	Schlegelmulchgerät, 2-2.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flail mower	Schlegelmulchgerät, Dreipunktanbau	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
distributing wood chips, levelling	Schnitzel verteilen, ausebnen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
celery harvestor	Sellerievollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 2 rows	Setzmaschine, 2-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 3 rows, middle	Setzmaschine, 3-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 3 rows, fast	Setzmaschine, 3-reihig, schnell	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
forage harvester, self-propelled, 4 row	Silohäcksler selbstfahrend 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spading machine	Spatenmaschine	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
self-propelled sprayer, 8 kW	Sprühgerät, selbstfahrend, 8 kW	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bale lifter/grab/stacker & bale trailer	Stroh, Heu laden + einführen, Grossballen	ha	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
distributing straw with agricultural trai	Stroheinlage mit Pneuwagen, 5 t	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tobacco harvester, 2 rows, without lift	Tabakernter 2-reihig, ohne Lift (12Pers)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tobacco planter	Tabaksetzmaschine	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tillage after harvest or before harvest	Unterfahren mit Messer	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
plastic mulch roller and unroller	Vlies verlegen und aufrollen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

english	german	Unit	Summer oat, OeLN intensive, wholesale	Summer oat, OeLN extensive, wholesale	Summer oat, organic, wholesale	Fava beans, OeLN intensive, wholesale	Fava beans, OeLN, wholesale	Fava beans, organic, wholesale	Protein peas, OeLN intensive, wholesale	Protein peas, OeLN, wholesale	Protein peas, organic, wholesale	Sunflower, OeLN intensive, wholesale	Sunflower, OeLN, wholesale	Sunflower, organic, wholesale	Rapeseed, OeLN intensive, wholesale	Rapeseed, OeLN, wholesale	Rapeseed, organic, wholesale	Soy, OeLN intensive, wholesale	Soy, OeLN, wholesale	Soy, organic, wholesale	Grain maize, OeLN intensive, wholesale	Grain maize, OeLN, wholesale	Grain maize, organic, wholesale	Corncob mix, OeLN intensive, from field	Corncob mix, OeLN, from field	Corncob mix, organic, from field	Silage maize, OeLN intensive, standing from field	Silage maize, OeLN, standing from field	Silage maize, organic, standing from field
10 t tandem-axle tipping trailers, hydra	10 t-Tandemkipper hydr., 2-Achs	ha	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0
2-mouldboard plough	2-Schar-Pflug	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3t agricultural trailer, 2 axles	3 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-mouldboard plough	4-Schar-Pflug	ha	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5t agricultural trailer, 2 axles	5 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8t agricultural trailer, 2 axles	8 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flame weeder mounted, 3m, 4 rows	Abflammen mit Traktor, 3 m, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
chopper equipment	Abfräsen von Kraut und Strünken	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
transport off the field and conditioning	Abtransport vom Feld und Aufbereitung	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed sprayer, 500l	Anbaugebläsespritze, 500 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed sprayer, 1000l	Anhängegebläsespritze, 1000 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvestor	Ausfahren mit Schüttelroder	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tractor-mounted tree shaker	Baumschüttler, hydraulisch, 3-Punkt	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
precision seed drills, 3m	Bestellkombination, 3 m	ha	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
irrigation with tractor pump, 100m irrig	Bewässern mit Traktorpumpe, 100 m Rohr	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cultivator, 2.5m	Bodenfräse, 2.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bedformer	Dammformer für Beeren	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tractor (diverse tractor hours)	Diverse Zugkraftstunden	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hay merger, 5.5-6.5m	Doppelschwader Mitenabl 5.5-6.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seed driller, 4 rows, 3m	Einzelkornsämaschine, 4-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
seed driller, 5 rows	Einzelkornsämaschine, 5-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seed driller, 6 rows, 3m	Einzelkornsämaschine, 6-reihig, 3 m	ha	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailer for 4 pallet boxes (PALOXE)	Erntewagen für 4 Grosskisten	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seedbed cultivators, 3m with roller	Federzinkenegge, 3 m mit Krümler	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, 12m	Feldspritze, 12 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, 15m	Feldspritze, 15 m	ha	3.0	2.0	0.0	2.0	1.0	0.0	2.0	1.0	0.0	1.0	1.0	0.0	3.0	2.0	0.0	2.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0
mower and mower conditioner, 3m	Frontkreiselmäher + Heckaufbereiter 3m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
loader waggon, >20 m3/5 t FS	Futterernte Ladewagen, >20 m3/5 t FS	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0
beet harvester + conveyor belt	Futterrübenernter + Überladeband	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, 200-300l	Gebläsespritze, 200-300 l, Dreipunktanbau	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed overseeder with roller, 3m	Grassämaschine mit Walze, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cultivator with roller, 3m	Grubber mit Nachläufer, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
disc spreader, 1000l	Grunddüngung, Schleuderstreuer, 1000 l	ha	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0
disc spreader, 450l	Grunddüngung, Schleuderstreuer, 450 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
manure tanker vacuum, 4m3	Güllen, 4 m3-Vakuumfass, pro m3	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
manure tanker with row crop injector,	Güllen, Schleppschlauch 6 m3-Pumpf. ; pro m3	ha	0.0	1.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0
mechanical weeding, finger weeder, 5	Hackbürste, 5-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 2 rows	Hacken/Häufeln, 2-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 3 rows	Hacken/Häufeln, 3-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 4 rows	Hacken/Häufeln, 4-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tined weeder, 6m	Hackstriegel, 6 m	ha	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	2.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0
tined weeder, 9m, hydraulic	Hackstriegel, 9 m hydraulisch	ha	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hydraulic lift, self-propelled, by electri	Hebebühne schwer, selbstfahrend, el.	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, folding arms, 400l	Herbizidfass 400 l mit Balken beidseitig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
carrot harvester	Karottenvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
row crop cultivator, 4 rows	Kartoffelhack- und häufelgerät, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato haulm topper, 4 rows	Kartoffelkrautschläger, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato planter, 4 rows	Kartoffellegeautomat, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato harvester, 1 row	Kartoffelvollernter, 1-reihig, Rollboden	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed muck spreader for orachards, 3	Kompoststreuer für Obstanlagen, 3 m3	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
disc spreader, 1000l	Kopfdüngung, Schleuderstreuer, 1000 l	ha	3.0	2.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	2.0	1.0	0.0	3.0	1.0	0.0	1.0	0.0	0.0	2.0	1.0	0.0	2.0	1.0	0.0	2.0	1.0	0.0
disc spreader, 450l	Kopfdüngung, Schleuderstreuer, 450 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet defoliator, 6 rows	Köpfroder 6-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spreader for slug pellets	Körnerstreuer (Schnecken)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
power harrow, 3m	Kreiselegge, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	2.0	0.0	0.0	2.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
rakes/tedder, 6.1-7.5 m	Kreiselheuer, 6.1-7.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rotary mower, 2.1-2.6m	Kreiselmäher, 2.1-2.6 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailer for distributing empty boxes	Leeres Gebinde verteilen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvester, 150 kW (soybean, peas)	Mähdrescher, 150 kW (Soja, Erbsen)	ha	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvester, 150 kW (cereal, beans)	Mähdrescher, 150kW (Getreide, Ackerbohnen)	ha	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvester, 90 kW (maize, CCM)	Mähdrescher, 90 kW (Mais, CCM)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0
Maize cultivator, 4 rows, 3m, 2 pers.	Maisscharhackgerät, 4-reihig, 3 m, 2 Pers.	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	2.0	0.0	0.0	2.0
Maize cultivator, 4 rows, 3m	Maissternhackgerät, 4-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0
trailed muck spreader, hydraulic, 3t	Misten, Hydrauliklader, 3 t-Zetter, pro t	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed muck spreader, hydraulic, 7t	Misten, Hydrauliklader, 7 t-Zetter, pro t	ha	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0
motor-mowers, 1.9m	Motormäher, 1.9 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted chopper, 2.8m	Mulchgerät mit Schwenkarm, 2.8 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cultivator, 3m	Nachbearbeitung, Grubber, 3 m	ha	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
maintenance of ecological compensati	Pflege Wildkrautstreifen (Schnitt, Erneuern)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
levelling blade for tractors	Planierschild zu Traktor	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
square baler big	Quaderballenpresse gross	ha	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
conveyor belt	Querförderband	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beetroot harvester	Randenvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
roller, 3m	Rauwalze, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rotary hoe, 5 rows 50cm	Reihenhackfräse, 5-reihig 50 cm	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
vegetable harvostor (brussel sprouts)	Rosenkohlvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet row hoe, 6 rows, 3m, 2 pers	Rübenscharhackgerät, 6-reihig, 3 m, 2 Pers.	ha	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet row hoe, 6 rows, 3m	Rübensternhackgerät, 6-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
round baler	Rundballenpresse mittel, Netzbindung	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted seeder, 3m	Sämaschine, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flail mower, 2-2.5m	Schlegelmulchgerät, 2-2.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flail mower	Schlegelmulchgerät, Dreipunktanbau	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
distributing wood chips, levelling	Schnitzel verteilen, ausebnen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
celery harvestor	Sellerievollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 2 rows	Setzmaschine, 2-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 3 rows, middle	Setzmaschine, 3-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 3 rows, fast	Setzmaschine, 3-reihig, schnell	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
forage harvester, self-propelled, 4 row	Silohäcksler selbstfahrend 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0
spading machine	Spatenmaschine	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
self-propelled sprayer, 8 kW	Sprühgerät, selbstfahrend, 8 kW	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bale lifter/grab/stacker & bale trailer	Stroh, Heu laden + einführen, Grossballen	ha	1.2	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
distributing straw with agricultural trai	Stroheinlage mit Pneuwagen, 5 t	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tobacco harvester, 2 rows, without lift	Tabakernter 2-reihig, ohne Lift (12Pers)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tobacco planter	Tabaksetzmaschine	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tillage after harvest or before harvest	Unterfahren mit Messer	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
plastic mulch roller and unroller	Vlies verlegen und aufrollen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

english	german	Unit	Sugar beet, OeLN intensive, wholesale	Sugar beet, OeLN, wholesale	Sugar beet, organic, wholesale	Fodder beet, OeLN intensive, wholesale	Fodder beet, OeLN, wholesale	Fodder beet, organic, wholesale	Tobacco, Burley, OeLN, air dried	Tobacco, Virgine, OeLN, air dried	Potatoes, OeLN intensive, wholesale	Potatoes, OeLN, wholesale	Potatoes, organic, wholesale	Potatoes, OeLN intensive, retail	Potatoes, OeLN, retail	Potatoes, organic, retail	Processing potatoes, OeLN intensive, wholesale	Processing potatoes, OeLN, wholesale	Processing potatoes, organic, wholesale	Meadow, OeLN intensive	Meadow, OeLN	Meadow, organic	Meadow forage, OeLN intensive, sale	Meadow forage, OeLN, sale	Meadow forage, organic, sale	Machine beans, OeLN	Machine beans, organic	Threshing peas, OeLN	Threshing peas, organic
10 t tandem-axle tipping trailers, hydra	10 t-Tandemkipper hydr., 2-Achs	ha	1.2	1.2	1.2	1.2	1.2	1.2	0.0	0.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-mouldboard plough	2-Schar-Pflug	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0
3t agricultural trailer, 2 axles	3 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-mouldboard plough	4-Schar-Pflug	ha	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0
5t agricultural trailer, 2 axles	5 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8t agricultural trailer, 2 axles	8 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flame weeder mounted, 3m, 4 rows	Abflammen mit Traktor, 3 m, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
chopper equipment	Abfräsen von Kraut und Strünken	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
transport off the field and conditioning	Abtransport vom Feld und Aufbereitung	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0
trailed sprayer, 500l	Anbaugebläsespritze, 500 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed sprayer, 1000l	Anhängegebläsespritze, 1000 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvestor	Ausfahren mit Schüttelroder	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tractor-mounted tree shaker	Baumschüttler, hydraulisch, 3-Punkt	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
precision seed drills, 3m	Bestellkombination, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.5	0.5	0.0	0.0	0.0	0.0
irrigation with tractor pump, 100m irrig	Bewässern mit Traktorpumpe, 100 m Rohr	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	10.0	10.0	10.0
cultivator, 2.5m	Bodenfräse, 2.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
bedformer	Dammformer für Beeren	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tractor (diverse tractor hours)	Diverse Zugkraftstunden	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0
hay merger, 5.5-6.5m	Doppelschwader Mitenabl 5.5-6.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	3.4	3.4	7.0	7.0	7.0	0.0	0.0	0.0	0.0
seed driller, 4 rows, 3m	Einzelkornsämaschine, 4-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seed driller, 5 rows	Einzelkornsämaschine, 5-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seed driller, 6 rows, 3m	Einzelkornsämaschine, 6-reihig, 3 m	ha	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailer for 4 pallet boxes (PALOXE)	Erntewagen für 4 Grosskisten	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seedbed cultivators, 3m with roller	Federzinkenegge, 3 m mit Krümler	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	1.0
mounted sprayer, 12m	Feldspritze, 12 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	3.0	1.0
mounted sprayer, 15m	Feldspritze, 15 m	ha	4.0	2.0	0.0	3.0	2.0	0.0	7.0	7.0	9.0	6.0	3.0	9.0	6.0	3.0	9.0	6.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mower and mower conditioner, 3m	Frontkreiselmäher + Heckaufbereiter 3m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.7	1.7	4.0	4.0	4.0	0.0	0.0	0.0	0.0
loader waggon, >20 m3/5 t FS	Futterernte Ladewagen, >20 m3/5 t FS	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	5.4	5.4	6.0	5.4	5.4	0.0	0.0	0.0	0.0
beet harvester + conveyor belt	Futterrübenernter + Überladeband	ha	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, 200-300l	Gebläsespritze, 200-300 l, Dreipunktanbau	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed overseeder with roller, 3m	Grassämaschine mit Walze, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0
cultivator with roller, 3m	Grubber mit Nachläufer, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.5
disc spreader, 1000l	Grunddüngung, Schleuderstreuer, 1000 l	ha	2.0	2.0	1.0	2.0	2.0	0.0	2.0	2.0	2.0	1.0	0.0	2.0	1.0	0.0	2.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
disc spreader, 450l	Grunddüngung, Schleuderstreuer, 450 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0
manure tanker vacuum, 4m3	Güllen, 4 m3-Vakuumfass, pro m3	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
manure tanker with row crop injector,	Güllen, Schleppschlauch 6 m3-Pumpf. ; pro m3	ha	0.0	1.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	1.5	2.0	3.0	0.0	1.5	3.0	0.0	0.0	0.0	0.0
mechanical weeding, finger weeder, 5	Hackbürste, 5-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 2 rows	Hacken/Häufeln, 2-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 3 rows	Hacken/Häufeln, 3-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 4 rows	Hacken/Häufeln, 4-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tined weeder, 6m	Hackstriegel, 6 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tined weeder, 9m, hydraulic	Hackstriegel, 9 m hydraulisch	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
hydraulic lift, self-propelled, by electri	Hebebühne schwer, selbstfahrend, el.	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, folding arms, 400l	Herbizidfass 400 l mit Balken beidseitig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
carrot harvester	Karottenvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
row crop cultivator, 4 rows	Kartoffelhack- und häufelgerät, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato haulm topper, 4 rows	Kartoffelkrautschläger, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato planter, 4 rows	Kartoffellegeautomat, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato harvester, 1 row	Kartoffelvollernter, 1-reihig, Rollboden	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed muck spreader for orachards, 3r	Kompoststreuer für Obstanlagen, 3 m3	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
disc spreader, 1000l	Kopfdüngung, Schleuderstreuer, 1000 l	ha	3.0	2.0	0.0	3.0	2.0	0.0	0.0	0.0	2.0	2.0	0.0	2.0	2.0	0.0	2.0	2.0	0.0	2.0	1.0	0.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0
disc spreader, 450l	Kopfdüngung, Schleuderstreuer, 450 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0
beet defoliator, 6 rows	Köpfroder 6-reihig	ha	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spreader for slug pellets	Körnerstreuer (Schnecken)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
power harrow, 3m	Kreiselegge, 3 m	ha	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	0.5	0.0	0.0	0.5	0.0	0.0	2.0	0.0	1.6	1.6
rakes/tedder, 6.1-7.5 m	Kreiselheuer, 6.1-7.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	3.4	3.4	7.0	7.0	7.0	0.0	0.0	0.0	0.0
rotary mower, 2.1-2.6m	Kreiselmäher, 2.1-2.6 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailer for distributing empty boxes	Leeres Gebinde verteilen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvester, 150 kW (soybean, peas)	Mähdrescher, 150 kW (Soja, Erbsen)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvester, 150 kW (cereal, beans)	Mähdrescher, 150kW (Getreide, Ackerbohnen)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvester, 90 kW (maize, CCM)	Mähdrescher, 90 kW (Mais, CCM)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maize cultivator, 4 rows, 3m, 2 pers.	Maisscharhackgerät, 4-reihig, 3 m, 2 Pers.	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maize cultivator, 4 rows, 3m	Maissternhackgerät, 4-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed muck spreader, hydraulic, 3t	Misten, Hydrauliklader, 3 t-Zetter, pro t	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed muck spreader, hydraulic, 7t	Misten, Hydrauliklader, 7 t-Zetter, pro t	ha	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
motor-mowers, 1.9m	Motormäher, 1.9 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.7	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted chopper, 2.8m	Mulchgerät mit Schwenkarm, 2.8 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cultivator, 3m	Nachbearbeitung, Grubber, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
maintenance of ecological compensati	Pflege Wildkrautstreifen (Schnitt, Erneuern)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
levelling blade for tractors	Planierschild zu Traktor	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
square baler big	Quaderballenpresse gross	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
conveyor belt	Querförderband	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beetroot harvester	Randenvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
roller, 3m	Rauwalze, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0
rotary hoe, 5 rows 50cm	Reihenhackfräse, 5-reihig 50 cm	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.0	0.0	0.0
vegetable harvostor (brussel sprouts)	Rosenkohlvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet row hoe, 6 rows, 3m, 2 pers	Rübenscharhackgerät, 6-reihig, 3 m, 2 Pers.	ha	0.0	0.0	3.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet row hoe, 6 rows, 3m	Rübensternhackgerät, 6-reihig, 3 m	ha	1.0	2.0	0.0	1.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
round baler	Rundballenpresse mittel, Netzbindung	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
mounted seeder, 3m	Sämaschine, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0
flail mower, 2-2.5m	Schlegelmulchgerät, 2-2.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flail mower	Schlegelmulchgerät, Dreipunktanbau	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
distributing wood chips, levelling	Schnitzel verteilen, ausebnen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
celery harvestor	Sellerievollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 2 rows	Setzmaschine, 2-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 3 rows, middle	Setzmaschine, 3-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 3 rows, fast	Setzmaschine, 3-reihig, schnell	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
forage harvester, self-propelled, 4 row	Silohäcksler selbstfahrend 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spading machine	Spatenmaschine	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
self-propelled sprayer, 8 kW	Sprühgerät, selbstfahrend, 8 kW	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bale lifter/grab/stacker & bale trailer	Stroh, Heu laden + einführen, Grossballen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.5	1.5	1.5	1.5	1.5	0.0	0.0	0.0	0.0
distributing straw with agricultural trai	Stroheinlage mit Pneuwagen, 5 t	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tobacco harvester, 2 rows, without lift	Tabakernter 2-reihig, ohne Lift (12Pers)	ha	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tobacco planter	Tabaksetzmaschine	ha	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tillage after harvest or before harvest	Unterfahren mit Messer	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
plastic mulch roller and unroller	Vlies verlegen und aufrollen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

machinery	
engl	**german**
10 t tandem-axle tipping trailers, hydraulic, 2 axles	10 t-Tandemkipper hydr., 2-Achs
2-mouldboard plough	2-Schar-Pflug
3t agricultural trailer, 2 axles	3 t-Pneuwagen, 2-Achs
4-mouldboard plough	4-Schar-Pflug
5t agricultural trailer, 2 axles	5 t-Pneuwagen, 2-Achs
8t agricultural trailer, 2 axles	8 t-Pneuwagen, 2-Achs
flame weeder mounted, 3m, 4 rows	Abflammen mit Traktor, 3 m, 4-reihig
chopper equipment	Abfräsen von Kraut und Strünken
transport off the field and conditioning	Abtransport vom Feld und Aufbereitung
trailed sprayer, 500l	Anbaugebläsespritze, 500 l
trailed sprayer, 1000l	Anhängegebläsespritze, 1000 l
harvestor	Ausfahren mit Schüttelroder
tractor-mounted tree shaker	Baumschüttler, hydraulisch, 3-Punkt
precision seed drills, 3m	Bestellkombination, 3 m
irrigation with tractor pump, 100m irrigation pipe	Bewässern mit Traktorpumpe, 100 m Rohr
cultivator, 2.5m	Bodenfräse, 2.5 m
bedformer	Dammformer für Beeren
tractor (diverse tractor hours)	Diverse Zugkraftstunden
hay merger, 5.5-6.5m	Doppelschwader Mitenabl 5.5-6.5 m
seed driller, 4 rows, 3m	Einzelkornsämaschine, 4-reihig, 3 m
seed driller, 5 rows	Einzelkornsämaschine, 5-reihig
seed driller, 6 rows, 3m	Einzelkornsämaschine, 6-reihig, 3 m
trailer for 4 pallet boxes (PALOXE)	Erntewagen für 4 Grosskisten
seedbed cultivators, 3m with roller	Federzinkenegge, 3 m mit Krümler
mounted sprayer, 12m	Feldspritze, 12 m
mounted sprayer, 15m	Feldspritze, 15 m
mower and mower conditioner, 3m	Frontkreiselmäher + Heckaufbereiter 3m
loader waggon, >20 m3/5 t FS	Futterernte Ladewagen, >20 m3/5 t FS
beet harvester + conveyor belt	Futterrübenernter + Überladeband
mounted sprayer, 200-300l	Gebläsespritze, 200-300 l, Dreipunktanbau
trailed overseeder with roller, 3m	Grassämaschine mit Walze, 3 m
cultivator with roller, 3m	Grubber mit Nachläufer, 3 m
disc spreader, 1000l	Grunddüngung, Schleuderstreuer, 1000 l
disc spreader, 450l	Grunddüngung, Schleuderstreuer, 450 l
manure tanker vacuum, 4m3	Güllen, 4 m3-Vakuumfass, pro m3
manure tanker with row crop injector, 6m3	Güllen, Schleppschlauch 6 m3-Pumpf. ; pro m3
mechanical weeding, finger weeder, 5 rows	Hackbürste, 5-reihig
trailed row hoe, 2 rows	Hacken/Häufeln, 2-reihig, mittel
trailed row hoe, 3 rows	Hacken/Häufeln, 3-reihig, mittel
trailed row hoe, 4 rows	Hacken/Häufeln, 4-reihig, mittel
tined weeder, 6m	Hackstriegel, 6 m
tined weeder, 9m, hydraulic	Hackstriegel, 9 m hydraulisch
hydraulic lift, self-propelled, by electricity	Hebebühne schwer, selbstfahrend, el.
mounted sprayer, folding arms, 400l	Herbizidfass 400 l mit Balken beidseitig
carrot harvester	Karottenvollernter
row crop cultivator, 4 rows	Kartoffelhack- und häufelgerät, 4-reihig
potato haulm topper, 4 rows	Kartoffelkrautschläger, 4-reihig
potato planter, 4 rows	Kartoffellegeautomat, 4-reihig
potato harvester, 1 row	Kartoffelvollernter, 1-reihig, Rollboden
trailed muck spreader for orachards, 3m3	Kompoststreuer für Obstanlagen, 3 m3
disc spreader, 1000l	Kopfdüngung, Schleuderstreuer, 1000 l
disc spreader, 450l	Kopfdüngung, Schleuderstreuer, 450 l
beet defoliator, 6 rows	Köpfroder 6-reihig
spreader for slug pellets	Körnerstreuer (Schnecken)
power harrow, 3m	Kreiselegge, 3 m
rakes/tedder, 6.1-7.5 m	Kreiselheuer, 6.1-7.5 m
rotary mower, 2.1-2.6m	Kreiselmäher, 2.1-2.6 m
trailer for distributing empty boxes	Leeres Gebinde verteilen
harvester, 150 kW (soybean, peas)	Mähdrescher, 150 kW (Soja, Erbsen)
harvester, 150 kW (cereal, beans)	Mähdrescher, 150kW (Getreide, Ackerbohnen)
harvester, 90 kW (maize, CCM)	Mähdrescher, 90 kW (Mais, CCM)
Maize cultivator, 4 rows, 3m, 2 pers.	Maisscharhackgerät, 4-reihig, 3 m, 2 Pers.
Maize cultivator, 4 rows, 3m	Maissternhackgerät, 4-reihig, 3 m
trailed muck spreader, hydraulic, 3t	Misten, Hydrauliklader, 3 t-Zetter, pro t
trailed muck spreader, hydraulic, 7t	Misten, Hydrauliklader, 7 t-Zetter, pro t
motor-mowers, 1.9m	Motormäher, 1.9 m
mounted chopper, 2.8m	Mulchgerät mit Schwenkarm, 2.8 m
cultivator, 3m	Nachbearbeitung, Grubber, 3 m
maintenance of ecological compensation area (cutting, renewing)	Pflege Wildkrautstreifen (Schnitt, Erneuern)
levelling blade for tractors	Planierschild zu Traktor
square baler big	Quaderballenpresse gross
conveyor belt	Querförderband
beetroot harvester	Randenvollernter
roller, 3m	Rauwalze, 3 m
rotary hoe, 5 rows 50cm	Reihenhackfräse, 5-reihig 50 cm
vegetable harvostor (brussel sprouts)	Rosenkohlvollernter
beet row hoe, 6 rows, 3m, 2 pers	Rübenscharhackgerät, 6-reihig, 3 m, 2 Pers.
beet row hoe, 6 rows, 3m	Rübensternhackgerät, 6-reihig, 3 m
round baler	Rundballenpresse mittel, Netzbindung
mounted seeder, 3m	Sämaschine, 3 m
flail mower, 2-2.5m	Schlegelmulchgerät, 2-2.5 m
flail mower	Schlegelmulchgerät, Dreipunktanbau
distributing wood chips, levelling	Schnitzel verteilen, ausebnen
celery harvestor	Sellerievollernter
planter, 2 rows	Setzmaschine, 2-reihig
planter, 3 rows, middle	Setzmaschine, 3-reihig, mittel
planter, 3 rows, fast	Setzmaschine, 3-reihig, schnell
forage harvester, self-propelled, 4 rows	Silohäcksler selbstfahrend 4-reihig
spading machine	Spatenmaschine
self-propelled sprayer, 8 kW	Sprühgerät, selbstfahrend, 8 kW
bale lifter/grab/stacker & bale trailer	Stroh, Heu laden + einführen, Grossballen
distributing straw with agricultural trailer, 5t	Stroheinlage mit Pneuwagen, 5 t
tobacco harvester, 2 rows, without lift (12 pers.)	Tabakernter 2-reihig, ohne Lift (12Pers)
tobacco planter	Tabaksetzmaschine
tillage after harvest or before harvest due to bad yield (horticulture)	Unterfahren mit Messer
plastic mulch roller and unroller	Vlies verlegen und aufrollen

crop	
english	**german**
Winter wheat TOP, OeLN intensive, wholesale	Winterweizen Top ÖLN intensiv Grosshandel
Winter wheat TOP, OeLN extensive, wholesale	Winterweizen Top ÖLN Extenso Grosshandel
Winter wheat TOP, organic, wholesale	Winterweizen Top Bio Grosshandel
Winter wheat TOP, OeLN extensive, retail	Winterweizen Top ÖLN Extenso Einzelhandel
Winter wheat TOP, organic, retail	Winterweizen Top Bio Einzelhandel
Summer wheat TOP, OeLN intensive, wholesale	Sommerweizen Top ÖLN intensiv Grosshandel
Summer wheat TOP, OeLN extensive, wholesale	Sommerweizen Top ÖLN Extenso Grosshandel
Summer wheat TOP, organic, wholesale	Sommerweizen Top Bio Grosshandel
Spelt, OeLN intensive, wholesale	Dinkel ÖLN intensiv Grosshandel
Spelt, OeLN extensive, wholesale	Dinkel ÖLN Extenso Grosshandel
Spelt, organic, wholesale	Dinkel Bio Grosshandel
Spelt, OeLN extensive, retail	Dinkel ÖLN Extenso Einzelhandel
Spelt, organic, retail	Dinkel Bio Einzelhandel
Rye, OeLN intensive, wholesale	Roggen ÖLN intensiv Grosshandel
Rye, OeLN extensive, wholesale	Roggen ÖLN Extenso Grosshandel
Rye, organic, wholesale	Roggen Bio Grosshandel
Rye, OeLN extensive, retail	Roggen ÖLN Extenso Einzelhandel
Rye, organic, retail	Roggen Bio Einzelhandel
Emmer, organic, wholesale	Emmer Bio Grosshandel
Oat, OeLN extensive, retail	Speisehafer ÖLN Extenso Einzelhandel
Oat, organic, retail	Speisehafer Bio Einzelhandel
Triticale, OeLN intensive, wholesale	Triticale ÖLN intensiv Grosshandel
Triticale, OeLN extensive, wholesale	Triticale ÖLN Extenso Grosshandel
Triticale, organic, wholesale	Triticale Bio Grosshandel
Winter barley, OeLN intensive, wholesale	Wintergerste ÖLN intensiv Grosshandel
Winter barley, OeLN extensive, wholesale	Wintergerste ÖLN Extenso Grosshandel
Winter barley, organic, wholesale	Wintergerste Bio Grosshandel
Summer oat, OeLN intensive, wholesale	Sommerhafer ÖLN intensiv Grosshandel
Summer oat, OeLN extensive, wholesale	Sommerhafer ÖLN Extenso Grosshandel
Summer oat, organic, wholesale	Sommerhafer Bio Grosshandel
Fava beans, OeLN intensive, wholesale	Ackerbohnen ÖLN intensiv Grosshandel
Fava beans, OeLN, wholesale	Ackerbohnen ÖLN Grosshandel
Fava beans, organic, wholesale	Ackerbohnen Bio Grosshandel
Protein peas, OeLN intensive, wholesale	Eisweisserbsen ÖLN intensiv Grosshandel
Protein peas, OeLN, wholesale	Eisweisserbsen ÖLN Grosshandel
Protein peas, organic, wholesale	Eiweisserbsen Bio Grosshandel
Sunflower, OeLN intensive, wholesale	Sonnenblumen ÖLN intensiv Grosshandel
Sunflower, OeLN, wholesale	Sonnenblumen ÖLN Grosshandel
Sunflower, organic, wholesale	Sonnenblumen Bio Grosshandel
Rapeseed, OeLN intensive, wholesale	Raps ÖLN intensiv Grosshandel
Rapeseed, OeLN, wholesale	Raps ÖLN Grosshandel
Rapeseed, organic, wholesale	Raps Bio Grosshandel
Soy, OeLN intensive, wholesale	Soja ÖLN intensiv Grosshandel
Soy, OeLN, wholesale	Soja ÖLN Grosshandel
Soy, organic, wholesale	Soja Bio Grosshandel (Tofuherstellung)
Grain maize, OeLN intensive, wholesale	Körnermais ÖLN intensiv Grosshandel
Grain maize, OeLN, wholesale	Körnermais ÖLN Grosshandel
Grain maize, organic, wholesale	Körnermais Bio Grosshandel
Corncob mix, OeLN intensive, from field	CCM ÖLN intensiv, ab Feldrand
Corncob mix, OeLN, from field	CCM ÖLN ab Feldrand
Corncob mix, organic, from field	CCM Bio ab Feldrand
Silage maize, OeLN intensive, standing from field	Silomais ÖLN, intensiv, stehend ab Feld
Silage maize, OeLN, standing from field	Silomais ÖLN stehend ab Feld
Silage maize, organic, standing from field	Silomais Bio stehend ab Feld
Sugar beet, OeLN intensive, wholesale	Zuckerrüben ÖLN INTENSIV, Grosshandel
Sugar beet, OeLN, wholesale	Zuckerrüben ÖLN Grosshandel
Sugar beet, organic, wholesale	Zuckerrüben Bio Grosshandel
Fodder beet, OeLN intensive, wholesale	Futterrüben ÖLN intensiv Grosshandel
Fodder beet, OeLN, wholesale	Futterrüben ÖLN Grosshandel
Fodder beet, organic, wholesale	Futterrüben Bio Grosshandel
Tobacco, Burley, OeLN, air dried	Tabak, Burley, ÖLN luftgetrocknet
Tobacco, Virgine, OeLN, air dried	Tabak, Virgine, ÖLN luftgetrocknet
Potatoes, OeLN intensive, wholesale	Speisekartoffeln ÖLN intensiv Grosshandel
Potatoes, OeLN, wholesale	Speisekartoffeln ÖLN Grosshandel
Potatoes, organic, wholesale	Speisekartoffeln Bio Grosshandel
Potatoes, OeLN intensive, retail	Speisekartoffeln ÖLN intensiv, Einzelhandel
Potatoes, OeLN, retail	Speisekartoffeln ÖLN Einzelhandel
Potatoes, organic, retail	Speisekartoffeln Bio Einzelhandel
Processing potatoes, OeLN intensive, wholesale	Speisekartoffeln ÖLN intensiv Grosshandel Veredelun
Processing potatoes, OeLN, wholesale	Speisekartoffeln ÖLN Grosshandel, Veredelung
Processing potatoes, organic, wholesale	Speisekartoffeln Bio Grosshanel, Veredelung
Meadow, OeLN intensive	Kunstwiese ÖLN intensiv
Meadow, OeLN	Kunstwiese ÖLN
Meadow, organic	Kunstwiese Bio
Meadow forage, OeLN intensive, sale	Kunstwiesenfutter ÖLN intensiv, Verkauf
Meadow forage, OeLN, sale	Kunstwiesenfutter ÖLN Verkauf
Meadow forage, organic, sale	Kunstwiesenfutter Bio Verkauf
Machine beans, OeLN	Maschinenbohnen, ÖLN
Machine beans, organic	Maschinenbohnen, Bio
Threshing peas, OeLN	Drescherbsen, ÖLN
Threshing peas, organic	Drescherbsen, Bio

organic full name	**conventional full name**	**short name for Figure 4**
Winter wheat TOP, organic, wholesale	Winter wheat TOP, OeLN intensive, wholesale	wheat, winter
Summer wheat TOP, organic, wholesale	Summer wheat TOP, OeLN intensive, wholesale	wheat, summer
Rye, organic, wholesale	Rye, OeLN intensive, wholesale	rye
Oat, organic, retail	Oat, OeLN extensive, retail	oat
Triticale, organic, wholesale	Triticale, OeLN intensive, wholesale	triticale
Winter barley, organic, wholesale	Winter barley, OeLN intensive, wholesale	barley, winter
Summer oat, organic, wholesale	Summer oat, OeLN intensive, wholesale	oat, summer
Fava beans, organic, wholesale	Fava beans, OeLN, wholesale	beans, fava
Protein peas, organic, wholesale	Protein peas, OeLN, wholesale	peas, protein
Sunflower, organic, wholesale	Sunflower, OeLN, wholesale	sunflower
Rapeseed, organic, wholesale	Rapeseed, OeLN, wholesale	rapeseed
Soy, organic, wholesale	Soy, OeLN, wholesale	soy
Grain maize, organic, wholesale	Grain maize, OeLN, wholesale	maize, grain
Corncob mix, organic, from field	Corncob mix, OeLN, from field	corncob mix
Silage maize, organic, standing from field	Silage maize, OeLN, standing from field	maize, silage
Sugar beet, organic, wholesale	Sugar beet, OeLN, wholesale	beet, sugar
Fodder beet, organic, wholesale	Fodder beet, OeLN, wholesale	beet, fodder
Potatoes, organic, wholesale	Potatoes, OeLN, wholesale	potatoes (3)
Potatoes, organic, retail	Potatoes, OeLN, retail	potatoes (3)
Processing potatoes, organic, wholesale	Processing potatoes, OeLN, wholesale	potatoes (3)
Meadow, organic	Meadow, OeLN	meadow
Meadow forage, organic, sale	Meadow forage, OeLN, sale	meadow forage
Machine beans, organic	Machine beans, OeLN	beans, machine
Threshing peas, organic	Threshing peas, OeLN	peas, threshing

11.7 Machinery data

english	german	Unit	Winter wheat TOP, OeLN intensive, wholesale	Winter wheat TOP, OeLN extensive, wholesale	Winter wheat TOP, organic, wholesale	Winter wheat TOP, OeLN extensive, retail	Winter wheat TOP, organic, retail	Summer wheat TOP, OeLN intensive, wholesale	Summer wheat TOP, OeLN extensive, wholesale	Summer wheat TOP, organic, wholesale	Spelt, OeLN intensive, wholesale	Spelt, OeLN extensive, wholesale	Spelt, organic, wholesale	Spelt, OeLN extensive, retail	Spelt, organic, retail	Rye, OeLN intensive, wholesale	Rye, OeLN extensive, wholesale	Rye, organic, wholesale	Rye, OeLN extensive, retail	Rye, organic, retail	Emmer, organic, wholesale	Oat, OeLN extensive, retail	Oat, organic, retail	Triticale, OeLN intensive, wholesale	Triticale, OeLN extensive, wholesale	Triticale, organic, wholesale	Winter barley, OeLN intensive, wholesale	Winter barley, OeLN extensive, wholesale	Winter barley, organic, wholesale
10 t tandem-axle tipping trailers, hydra	10 t-Tandemkipper hydr., 2-Achs	ha	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
2-mouldboard plough	2-Schar-Pflug	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3t agricultural trailer, 2 axles	3 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-mouldboard plough	4-Schar-Pflug	ha	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5t agricultural trailer, 2 axles	5 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8t agricultural trailer, 2 axles	8 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flame weeder mounted, 3m, 4 rows	Abflammen mit Traktor, 3 m, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
chopper equipment	Abfräsen von Kraut und Strünken	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
transport off the field and conditionin	Abtransport vom Feld und Aufbereitung	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed sprayer, 500l	Anbaugebläsespritze, 500 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed sprayer, 1000l	Anhängegebläsespritze, 1000 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvestor	Ausfahren mit Schüttelroder	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tractor-mounted tree shaker	Baumschüttler, hydraulisch, 3-Punkt	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
precision seed drills, 3m	Bestellkombination, 3 m	ha	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
irrigation with tractor pump, 100m irrig	Bewässern mit Traktorpumpe, 100 m Rohr	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cultivator, 2.5m	Bodenfräse, 2.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bedformer	Dammformer für Beeren	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tractor (diverse tractor hours)	Diverse Zugkraftstunden	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hay merger, 5.5-6.5m	Doppelschwader Mitenabl 5.5-6.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seed driller, 4 rows, 3m	Einzelkornsämaschine, 4-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seed driller, 5 rows	Einzelkornsämaschine, 5-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seed driller, 6 rows, 3m	Einzelkornsämaschine, 6-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailer for 4 pallet boxes (PALOXE)	Erntewagen für 4 Grosskisten	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seedbed cultivators, 3m with roller	Federzinkenegge, 3 m mit Krümler	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, 12m	Feldspritze, 12 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, 15m	Feldspritze, 15 m	ha	3.0	2.0	0.0	2.0	0.0	3.0	2.0	0.0	3.0	2.0	0.0	2.0	0.0	3.0	2.0	0.0	2.0	0.0	0.0	2.0	0.0	3.0	2.0	0.0	3.0	2.0	0.0
mower and mower conditioner, 3m	Frontkreiselmäher + Heckaufbereiter 3m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
loader waggon, >20 m3/5 t FS	Futterernte Ladewagen, >20 m3/5 t FS	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet harvester + conveyor belt	Futterrübenernter + Überladeband	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, 200-300l	Gebläsespritze, 200-300 l, Dreipunktanbau	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed overseeder with roller, 3m	Grassämaschine mit Walze, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cultivator with roller, 3m	Grubber mit Nachläufer, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
disc spreader, 1000l	Grunddüngung, Schleuderstreuer, 1000 l	ha	1.0	1.0	0.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	0.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
disc spreader, 450l	Grunddüngung, Schleuderstreuer, 450 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
manure tanker vacuum, 4m3	Güllen, 4 m3-Vakuumfass, pro m3	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
manure tanker with row crop injector,	Güllen, Schleppschlauch 6 m3-Pumpf. ; pro m3	ha	0.0	1.0	2.0	1.0	2.0	0.0	1.0	2.0	0.0	1.0	2.0	1.0	2.0	0.0	1.0	2.0	1.0	2.0	2.0	1.0	2.0	0.0	1.0	2.0	0.0	1.0	2.0
mechanical weeding, finger weeder, 5	Hackbürste, 5-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 2 rows	Hacken/Häufeln, 2-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 3 rows	Hacken/Häufeln, 3-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 4 rows	Hacken/Häufeln, 4-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tined weeder, 6m	Hackstriegel, 6 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tined weeder, 9m, hydraulic	Hackstriegel, 9 m hydraulisch	ha	0.0	0.0	3.0	0.0	3.0	0.0	0.0	2.0	0.0	0.0	2.0	0.0	2.0	0.0	0.0	3.0	0.0	3.0	2.0	0.0	3.0	0.0	0.0	2.0	0.0	0.0	2.0
hydraulic lift, self-propelled, by electr	Hebebühne schwer, selbstfahrend, el.	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, folding arms, 400l	Herbizidfass 400 l mit Balken beidseitig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
carrot harvester	Karottenvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
row crop cultivator, 4 rows	Kartoffelhack- und häufelgerät, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato haulm topper, 4 rows	Kartoffelkrautschläger, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato planter, 4 rows	Kartoffellegeautomat, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato harvester, 1 row	Kartoffelvollernter, 1-reihig, Rollboden	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed muck spreader for orachards, 3	Kompoststreuer für Obstanlagen, 3 m3	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
disc spreader, 1000l	Kopfdüngung, Schleuderstreuer, 1000 l	ha	3.0	2.0	0.0	2.0	0.0	3.0	2.0	1.0	3.0	2.0	0.0	2.0	0.0	3.0	2.0	0.0	2.0	0.0	0.0	2.0	0.0	3.0	2.0	0.0	3.0	2.0	0.0
disc spreader, 450l	Kopfdüngung, Schleuderstreuer, 450 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet defoliator, 6 rows	Köpfroder 6-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spreader for slug pellets	Körnerstreuer (Schnecken)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
power harrow, 3m	Kreiselegge, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rakes/tedder, 6.1-7.5 m	Kreiselheuer, 6.1-7.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rotary mower, 2.1-2.6m	Kreiselmäher, 2.1-2.6 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailer for distributing empty boxes	Leeres Gebinde verteilen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvester, 150 kW (soybean, peas)	Mähdrescher, 150 kW (Soja, Erbsen)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvester, 150 kW (cereal, beans)	Mähdrescher, 150kW (Getreide, Ackerbohnen)	ha	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
harvester, 90 kW (maize, CCM)	Mähdrescher, 90 kW (Mais, CCM)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maize cultivator, 4 rows, 3m, 2 pers.	Maisscharhackgerät, 4-reihig, 3 m, 2 Pers.	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maize cultivator, 4 rows, 3m	Maissternhackgerät, 4-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed muck spreader, hydraulic, 3t	Misten, Hydrauliklader, 3 t-Zetter, pro t	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed muck spreader, hydraulic, 7t	Misten, Hydrauliklader, 7 t-Zetter, pro t	ha	0.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0
motor-mowers, 1.9m	Motormäher, 1.9 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted chopper, 2.8m	Mulchgerät mit Schwenkarm, 2.8 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cultivator, 3m	Nachbearbeitung, Grubber, 3 m	ha	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
maintenance of ecological compensati	Pflege Wildkrautstreifen (Schnitt, Erneuern)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
levelling blade for tractors	Planierschild zu Traktor	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
square baler big	Quaderballenpresse gross	ha	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
conveyor belt	Querförderband	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beetroot harvester	Randenvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
roller, 3m	Rauwalze, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rotary hoe, 5 rows 50cm	Reihenhackfräse, 5-reihig 50 cm	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
vegetable harvostor (brussel sprouts)	Rosenkohlvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet row hoe, 6 rows, 3m, 2 pers	Rübenscharhackgerät, 6-reihig, 3 m, 2 Pers.	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet row hoe, 6 rows, 3m	Rübensternhackgerät, 6-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
round baler	Rundballenpresse mittel, Netzbindung	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted seeder, 3m	Sämaschine, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flail mower, 2-2.5m	Schlegelmulchgerät, 2-2.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flail mower	Schlegelmulchgerät, Dreipunktanbau	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
distributing wood chips, levelling	Schnitzel verteilen, ausebnen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
celery harvestor	Sellerievollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 2 rows	Setzmaschine, 2-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 3 rows, middle	Setzmaschine, 3-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 3 rows, fast	Setzmaschine, 3-reihig, schnell	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
forage harvester, self-propelled, 4 row	Silohäcksler selbstfahrend 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spading machine	Spatenmaschine	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
self-propelled sprayer, 8 kW	Sprühgerät, selbstfahrend, 8 kW	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bale lifter/grab/stacker & bale trailer	Stroh, Heu laden + einführen, Grossballen	ha	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
distributing straw with agricultural trai	Stroheinlage mit Pneuwagen, 5 t	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tobacco harvester, 2 rows, without lift	Tabakernter 2-reihig, ohne Lift (12Pers)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tobacco planter	Tabaksetzmaschine	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tillage after harvest or before harvest	Unterfahren mit Messer	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
plastic mulch roller and unroller	Vlies verlegen und aufrollen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Sum	14.4	13.4	13.4	13.4	13.4	14.4	13.4	13.4	14.4	13.4	12.4	13.4	12.4	14.4	13.4	13.4	13.4	13.4	12.4	13.4	13.4	13.4	12.4	12.4	13.4	12.4	12.4
	pairs of compaired organic-conventional		🟨		🟨			🟥		🟥						🟩		🟩				🟦	🟦	🟪		🟪	🟩		🟩
	Average number of passes organic		14.2																										
	Average number of passes OeLN		15																										
			Winter wheat TOP, OeLN intensive, wholesale	Winter wheat TOP, OeLN extensive, wholesale	Winter wheat TOP, organic, wholesale	Winter wheat TOP, OeLN extensive, retail	Winter wheat TOP, organic, retail	Summer wheat TOP, OeLN intensive, wholesale	Summer wheat TOP, OeLN extensive, wholesale	Summer wheat TOP, organic, wholesale	Spelt, OeLN intensive, wholesale	Spelt, OeLN extensive, wholesale	Spelt, organic, wholesale	Spelt, OeLN extensive, retail	Spelt, organic, retail	Rye, OeLN intensive, wholesale	Rye, OeLN extensive, wholesale	Rye, organic, wholesale	Rye, OeLN extensive, retail	Rye, organic, retail	Emmer, organic, wholesale	Oat, OeLN extensive, retail	Oat, organic, retail	Triticale, OeLN intensive, wholesale	Triticale, OeLN extensive, wholesale	Triticale, organic, wholesale	Winter barley, OeLN intensive, wholesale	Winter barley, OeLN extensive, wholesale	Winter barley, organic, wholesale
			14.4	13	13	13	13	14	13	13	14	13	12	13	12	14	13	13	13	13	12	13	13	13	12	12	13	12	12

english	german	Unit	Summer oat, OeLN intensive, wholesale	Summer oat, OeLN extensive, wholesale	Summer oat, organic, wholesale	Fava beans, OeLN intensive, wholesale	Fava beans, OeLN, wholesale	Fava beans, organic, wholesale	Protein peas, OeLN intensive, wholesale	Protein peas, OeLN, wholesale	Protein peas, organic, wholesale	Sunflower, OeLN intensive, wholesale	Sunflower, OeLN, wholesale	Sunflower, organic, wholesale	Rapeseed, OeLN intensive, wholesale	Rapeseed, OeLN, wholesale	Rapeseed, organic, wholesale	Soy, OeLN intensive, wholesale	Soy, OeLN, wholesale	Soy, organic, wholesale	Grain maize, OeLN intensive, wholesale	Grain maize, OeLN, wholesale	Grain maize, organic, wholesale	Corncob mix, OeLN intensive, from field	Corncob mix, OeLN, from field	Corncob mix, organic, from field	Silage maize, OeLN intensive, standing from field	Silage maize, OeLN, standing from field	Silage maize, organic, standing from field
10 t tandem-axle tipping trailers, hydra	10 t-Tandemkipper hydr., 2-Achs	ha	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0
2-mouldboard plough	2-Schar-Pflug	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3t agricultural trailer, 2 axles	3 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-mouldboard plough	4-Schar-Pflug	ha	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5t agricultural trailer, 2 axles	5 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8t agricultural trailer, 2 axles	8 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flame weeder mounted, 3m, 4 rows	Abflammen mit Traktor, 3 m, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
chopper equipment	Abfräsen von Kraut und Strünken	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
transport off the field and conditioning	Abtransport vom Feld und Aufbereitung	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed sprayer, 500l	Anbaugebläsespritze, 500 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed sprayer, 1000l	Anhängegebläsespritze, 1000 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvestor	Ausfahren mit Schüttelroder	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tractor-mounted tree shaker	Baumschüttler, hydraulisch, 3-Punkt	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
precision seed drills, 3m	Bestellkombination, 3 m	ha	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
irrigation with tractor pump, 100m irrig	Bewässern mit Traktorpumpe, 100 m Rohr	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cultivator, 2.5m	Bodenfräse, 2.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bedformer	Dammformer für Beeren	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tractor (diverse tractor hours)	Diverse Zugkraftstunden	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hay merger, 5.5-6.5m	Doppelschwader Mitenabl 5.5-6.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seed driller, 4 rows, 3m	Einzelkornsämaschine, 4-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
seed driller, 5 rows	Einzelkornsämaschine, 5-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seed driller, 6 rows, 3m	Einzelkornsämaschine, 6-reihig, 3 m	ha	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailer for 4 pallet boxes (PALOXE)	Erntewagen für 4 Grosskisten	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seedbed cultivators, 3m with roller	Federzinkenegge, 3 m mit Krümler	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, 12m	Feldspritze, 12 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, 15m	Feldspritze, 15 m	ha	3.0	2.0	0.0	2.0	1.0	0.0	2.0	1.0	0.0	1.0	1.0	0.0	3.0	2.0	0.0	2.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0
mower and mower conditioner, 3m	Frontkreiselmäher + Heckaufbereiter 3m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
loader waggon, >20 m3/5 t FS	Futterernte Ladewagen, >20 m3/5 t FS	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0
beet harvester + conveyor belt	Futterrübenernter + Überladeband	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, 200-300l	Gebläsespritze, 200-300 l, Dreipunktanbau	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed overseeder with roller, 3m	Grassämaschine mit Walze, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cultivator with roller, 3m	Grubber mit Nachläufer, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
disc spreader, 1000l	Grunddüngung, Schleuderstreuer, 1000 l	ha	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0
disc spreader, 450l	Grunddüngung, Schleuderstreuer, 450 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
manure tanker vacuum, 4m3	Güllen, 4 m3-Vakuumfass, pro m3	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
manure tanker with row crop injector,	Güllen, Schleppschlauch 6 m3-Pumpf. ; pro m3	ha	0.0	1.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0
mechanical weeding, finger weeder, 5	Hackbürste, 5-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 2 rows	Hacken/Häufeln, 2-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 3 rows	Hacken/Häufeln, 3-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 4 rows	Hacken/Häufeln, 4-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tined weeder, 6m	Hackstriegel, 6 m	ha	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	2.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0
tined weeder, 9m, hydraulic	Hackstriegel, 9 m hydraulisch	ha	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hydraulic lift, self-propelled, by electr	Hebebühne schwer, selbstfahrend, el.	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, folding arms, 400l	Herbizidfass 400 l mit Balken beidseitig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
carrot harvester	Karottenvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
row crop cultivator, 4 rows	Kartoffelhack- und häufelgerät, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato haulm topper, 4 rows	Kartoffelkrautschläger, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato planter, 4 rows	Kartoffellegeautomat, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato harvester, 1 row	Kartoffelvollernter, 1-reihig, Rollboden	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed muck spreader for orachards, 3	Kompoststreuer für Obstanlagen, 3 m3	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
disc spreader, 1000l	Kopfdüngung, Schleuderstreuer, 1000 l	ha	3.0	2.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	2.0	1.0	0.0	3.0	1.0	0.0	1.0	0.0	0.0	2.0	1.0	0.0	2.0	1.0	0.0	2.0	1.0	0.0
disc spreader, 450l	Kopfdüngung, Schleuderstreuer, 450 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet defoliator, 6 rows	Köpfroder 6-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spreader for slug pellets	Körnerstreuer (Schnecken)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
power harrow, 3m	Kreiselegge, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	2.0	0.0	0.0	2.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
rakes/tedder, 6.1-7.5 m	Kreiselheuer, 6.1-7.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rotary mower, 2.1-2.6m	Kreiselmäher, 2.1-2.6 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailer for distributing empty boxes	Leeres Gebinde verteilen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvester, 150 kW (soybean, peas)	Mähdrescher, 150 kW (Soja, Erbsen)	ha	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvester, 150 kW (cereal, beans)	Mähdrescher, 150kW (Getreide, Ackerbohnen)	ha	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvester, 90 kW (maize, CCM)	Mähdrescher, 90 kW (Mais, CCM)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0
Maize cultivator, 4 rows, 3m, 2 pers.	Maisscharhackgerät, 4-reihig, 3 m, 2 Pers.	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	2.0	0.0	0.0	2.0
Maize cultivator, 4 rows, 3m	Maissternhackgerät, 4-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0
trailed muck spreader, hydraulic, 3t	Misten, Hydrauliklader, 3 t-Zetter, pro t	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed muck spreader, hydraulic, 7t	Misten, Hydrauliklader, 7 t-Zetter, pro t	ha	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0
motor-mowers, 1.9m	Motormäher, 1.9 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted chopper, 2.8m	Mulchgerät mit Schwenkarm, 2.8 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cultivator, 3m	Nachbearbeitung, Grubber, 3 m	ha	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
maintenance of ecological compensati	Pflege Wildkrautstreifen (Schnitt, Erneuern)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
levelling blade for tractors	Planierschild zu Traktor	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
square baler big	Quaderballenpresse gross	ha	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
conveyor belt	Querförderband	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beetroot harvester	Randenvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
roller, 3m	Rauwalze, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rotary hoe, 5 rows 50cm	Reihenhackfräse, 5-reihig 50 cm	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
vegetable harvostor (brussel sprouts)	Rosenkohlvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet row hoe, 6 rows, 3m, 2 pers	Rübenscharhackgerät, 6-reihig, 3 m, 2 Pers.	ha	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet row hoe, 6 rows, 3m	Rübensternhackgerät, 6-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
round baler	Rundballenpresse mittel, Netzbindung	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted seeder, 3m	Sämaschine, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flail mower, 2-2.5m	Schlegelmulchgerät, 2-2.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flail mower	Schlegelmulchgerät, Dreipunktanbau	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
distributing wood chips, levelling	Schnitzel verteilen, ausebnen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
celery harvestor	Sellerievollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 2 rows	Setzmaschine, 2-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 3 rows, middle	Setzmaschine, 3-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 3 rows, fast	Setzmaschine, 3-reihig, schnell	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
forage harvester, self-propelled, 4 row	Silohäcksler selbstfahrend 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0
spading machine	Spatenmaschine	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
self-propelled sprayer, 8 kW	Sprühgerät, selbstfahrend, 8 kW	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bale lifter/grab/stacker & bale trailer	Stroh, Heu laden + einführen, Grossballen	ha	1.2	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
distributing straw with agricultural trai	Stroheinlage mit Pneuwagen, 5 t	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tobacco harvester, 2 rows, without lift	Tabakernter 2-reihig, ohne Lift (12Pers)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tobacco planter	Tabaksetzmaschine	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tillage after harvest or before harvest	Unterfahren mit Messer	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
plastic mulch roller and unroller	Vlies verlegen und aufrollen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Sum	13.4	12.4	12.4	8.2	6.2	7.2	10.2	6.2	7.2	10.2	8.2	8.2	14.2	10.2	9.2	9.2	7.2	8.2	9.2	10.2	10.2	8.0	9.0	9.0	9.0	10.0	10.0
	pairs of compaired organic-conventional																												
	Average number of passes organic																												
	Average number of passes OeLN																												
			Summer oat, OeLN intensive, wholesale	Summer oat, OeLN extensive, wholesale	Summer oat, organic, wholesale	Fava beans, OeLN intensive, wholesale	Fava beans, OeLN, wholesale	Fava beans, organic, wholesale	Protein peas, OeLN intensive, wholesale	Protein peas, OeLN, wholesale	Protein peas, organic, wholesale	Sunflower, OeLN intensive, wholesale	Sunflower, OeLN, wholesale	Sunflower, organic, wholesale	Rapeseed, OeLN intensive, wholesale	Rapeseed, OeLN, wholesale	Rapeseed, organic, wholesale	Soy, OeLN intensive, wholesale	Soy, OeLN, wholesale	Soy, organic, wholesale	Grain maize, OeLN intensive, wholesale	Grain maize, OeLN, wholesale	Grain maize, organic, wholesale	Corncob mix, OeLN intensive, from field	Corncob mix, OeLN, from field	Corncob mix, organic, from field	Silage maize, OeLN intensive, standing from field	Silage maize, OeLN, standing from field	Silage maize, organic, standing from field
			13	12	12	8.2	6.2	7.2	10	6.2	7.2	10	8.2	8.2	14	10	9.2	9.2	7.2	8.2	9.2	10	10	8	9	9	9	10	10

english	german	Unit	Sugar beet, OeLN intensive, wholesale	Sugar beet, OeLN, wholesale	Sugar beet, organic, wholesale	Fodder beet, OeLN intensive, wholesale	Fodder beet, OeLN, wholesale	Fodder beet, organic, wholesale	Tobacco, Burley, OeLN, air dried	Tobacco, Virgine, OeLN, air dried	Potatoes, OeLN intensive, wholesale	Potatoes, OeLN, wholesale	Potatoes, organic, wholesale	Potatoes, OeLN intensive, retail	Potatoes, OeLN, retail	Potatoes, organic, retail	Processing potatoes, OeLN intensive, wholesale	Processing potatoes, OeLN, wholesale	Processing potatoes, organic, wholesale	Meadow, OeLN intensive	Meadow, OeLN	Meadow, organic	Meadow forage, OeLN intensive, sale	Meadow forage, OeLN, sale	Meadow forage, organic, sale	Machine beans, OeLN	Machine beans, organic	Threshing peas, OeLN	Threshing peas, organic
10 t tandem-axle tipping trailers, hydra	10 t-Tandemkipper hydr., 2-Achs	ha	1.2	1.2	1.2	1.2	1.2	1.2	0.0	0.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2-mouldboard plough	2-Schar-Pflug	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0
3t agricultural trailer, 2 axles	3 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-mouldboard plough	4-Schar-Pflug	ha	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0
5t agricultural trailer, 2 axles	5 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8t agricultural trailer, 2 axles	8 t-Pneuwagen, 2-Achs	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flame weeder mounted, 3m, 4 rows	Abflammen mit Traktor, 3 m, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
chopper equipment	Abfräsen von Kraut und Strünken	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
transport off the field and conditioning	Abtransport vom Feld und Aufbereitung	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0
trailed sprayer, 500l	Anbaugebläsespritze, 500 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed sprayer, 1000l	Anhängegebläsespritze, 1000 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvestor	Ausfahren mit Schüttelroder	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tractor-mounted tree shaker	Baumschüttler, hydraulisch, 3-Punkt	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
precision seed drills, 3m	Bestellkombination, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.5	0.5	0.0	0.0	0.0	0.0
irrigation with tractor pump, 100m irrig	Bewässern mit Traktorpumpe, 100 m Rohr	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	10.0	10.0	10.0
cultivator, 2.5m	Bodenfräse, 2.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
bedformer	Dammformer für Beeren	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tractor (diverse tractor hours)	Diverse Zugkraftstunden	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0
hay merger, 5.5-6.5m	Doppelschwader Mitenabl 5.5-6.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	3.4	3.4	7.0	7.0	7.0	0.0	0.0	0.0	0.0
seed driller, 4 rows, 3m	Einzelkornsämaschine, 4-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seed driller, 5 rows	Einzelkornsämaschine, 5-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seed driller, 6 rows, 3m	Einzelkornsämaschine, 6-reihig, 3 m	ha	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailer for 4 pallet boxes (PALOXE)	Erntewagen für 4 Grosskisten	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
seedbed cultivators, 3m with roller	Federzinkenegge, 3 m mit Krümler	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	1.0
mounted sprayer, 12m	Feldspritze, 12 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	3.0	1.0
mounted sprayer, 15m	Feldspritze, 15 m	ha	4.0	2.0	0.0	3.0	2.0	0.0	7.0	7.0	9.0	6.0	3.0	9.0	6.0	3.0	9.0	6.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mower and mower conditioner, 3m	Frontkreiselmäher + Heckaufbereiter 3m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.7	1.7	4.0	4.0	4.0	0.0	0.0	0.0	0.0
loader waggon, >20 m3/5 t FS	Futterernte Ladewagen, >20 m3/5 t FS	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	5.4	5.4	6.0	5.4	5.4	0.0	0.0	0.0	0.0
beet harvester + conveyor belt	Futterrübenernter + Überladeband	ha	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, 200-300l	Gebläsespritze, 200-300 l, Dreipunktanbau	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed overseeder with roller, 3m	Grassämaschine mit Walze, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0
cultivator with roller, 3m	Grubber mit Nachläufer, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.5
disc spreader, 1000l	Grunddüngung, Schleuderstreuer, 1000 l	ha	2.0	2.0	1.0	2.0	2.0	0.0	2.0	2.0	2.0	1.0	0.0	2.0	1.0	0.0	2.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
disc spreader, 450l	Grunddüngung, Schleuderstreuer, 450 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0
manure tanker vacuum, 4m3	Güllen, 4 m3-Vakuumfass, pro m3	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
manure tanker with row crop injector,	Güllen, Schleppschlauch 6 m3-Pumpf. ; pro m3	ha	0.0	1.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	1.5	2.0	3.0	0.0	1.5	3.0	0.0	0.0	0.0	0.0
mechanical weeding, finger weeder, 5	Hackbürste, 5-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 2 rows	Hacken/Häufeln, 2-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 3 rows	Hacken/Häufeln, 3-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed row hoe, 4 rows	Hacken/Häufeln, 4-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tined weeder, 6m	Hackstriegel, 6 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tined weeder, 9m, hydraulic	Hackstriegel, 9 m hydraulisch	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
hydraulic lift, self-propelled, by electr	Hebebühne schwer, selbstfahrend, el.	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted sprayer, folding arms, 400l	Herbizidfass 400 l mit Balken beidseitig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
carrot harvester	Karottenvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
row crop cultivator, 4 rows	Kartoffelhack- und häufelgerät, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato haulm topper, 4 rows	Kartoffelkrautschläger, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato planter, 4 rows	Kartoffellegeautomat, 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
potato harvester, 1 row	Kartoffelvollernter, 1-reihig, Rollboden	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed muck spreader for orachards, 3	Kompoststreuer für Obstanlagen, 3 m3	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
disc spreader, 1000l	Kopfdüngung, Schleuderstreuer, 1000 l	ha	3.0	2.0	0.0	3.0	2.0	0.0	0.0	0.0	2.0	2.0	0.0	2.0	2.0	0.0	2.0	2.0	0.0	2.0	1.0	0.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0
disc spreader, 450l	Kopfdüngung, Schleuderstreuer, 450 l	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0
beet defoliator, 6 rows	Köpfroder 6-reihig	ha	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spreader for slug pellets	Körnerstreuer (Schnecken)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
power harrow, 3m	Kreiselegge, 3 m	ha	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	0.5	0.0	0.0	0.5	0.0	0.0	2.0	0.0	1.6	1.6
rakes/tedder, 6.1-7.5 m	Kreiselheuer, 6.1-7.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	3.4	3.4	7.0	7.0	7.0	0.0	0.0	0.0	0.0
rotary mower, 2.1-2.6m	Kreiselmäher, 2.1-2.6 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailer for distributing empty boxes	Leeres Gebinde verteilen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvester, 150 kW (soybean, peas)	Mähdrescher, 150 kW (Soja, Erbsen)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvester, 150 kW (cereal, beans)	Mähdrescher, 150kW (Getreide, Ackerbohnen)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
harvester, 90 kW (maize, CCM)	Mähdrescher, 90 kW (Mais, CCM)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maize cultivator, 4 rows, 3m, 2 pers.	Maisscharhackgerät, 4-reihig, 3 m, 2 Pers.	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maize cultivator, 4 rows, 3m	Maissternhackgerät, 4-reihig, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed muck spreader, hydraulic, 3t	Misten, Hydrauliklader, 3 t-Zetter, pro t	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
trailed muck spreader, hydraulic, 7t	Misten, Hydrauliklader, 7 t-Zetter, pro t	ha	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
motor-mowers, 1.9m	Motormäher, 1.9 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.7	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mounted chopper, 2.8m	Mulchgerät mit Schwenkarm, 2.8 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cultivator, 3m	Nachbearbeitung, Grubber, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
maintenance of ecological compensati	Pflege Wildkrautstreifen (Schnitt, Erneuern)	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
levelling blade for tractors	Planierschild zu Traktor	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
square baler big	Quaderballenpresse gross	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
conveyor belt	Querförderband	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beetroot harvester	Randenvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
roller, 3m	Rauwalze, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0
rotary hoe, 5 rows 50cm	Reihenhackfräse, 5-reihig 50 cm	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.0	0.0	0.0
vegetable harvostor (brussel sprouts)	Rosenkohlvollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet row hoe, 6 rows, 3m, 2 pers	Rübenscharhackgerät, 6-reihig, 3 m, 2 Pers.	ha	0.0	0.0	3.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
beet row hoe, 6 rows, 3m	Rübensternhackgerät, 6-reihig, 3 m	ha	1.0	2.0	0.0	1.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
round baler	Rundballenpresse mittel, Netzbindung	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
mounted seeder, 3m	Sämaschine, 3 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0
flail mower, 2-2.5m	Schlegelmulchgerät, 2-2.5 m	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flail mower	Schlegelmulchgerät, Dreipunktanbau	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
distributing wood chips, levelling	Schnitzel verteilen, ausebnen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
celery harvestor	Sellerievollernter	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 2 rows	Setzmaschine, 2-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 3 rows, middle	Setzmaschine, 3-reihig, mittel	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
planter, 3 rows, fast	Setzmaschine, 3-reihig, schnell	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
forage harvester, self-propelled, 4 row	Silohäcksler selbstfahrend 4-reihig	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spading machine	Spatenmaschine	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
self-propelled sprayer, 8 kW	Sprühgerät, selbstfahrend, 8 kW	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bale lifter/grab/stacker & bale trailer	Stroh, Heu laden + einführen, Grossballen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.5	1.5	1.5	1.5	1.5	0.0	0.0	0.0	0.0
distributing straw with agricultural trai	Stroheinlage mit Pneuwagen, 5 t	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tobacco harvester, 2 rows, without lift	Tabakernter 2-reihig, ohne Lift (12Pers)	ha	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tobacco planter	Tabaksetzmaschine	ha	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
tillage after harvest or before harvest (	Unterfahren mit Messer	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
plastic mulch roller and unroller	Vlies verlegen und aufrollen	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Sum	15.2	14.2	11.2	14.2	14.2	10.2	16.0	16.0	25.2	23.2	20.2	25.2	23.2	20.2	25.2	23.2	20.2	24.7	23.6	22.6	31.0	30.9	30.4	22.0	22.0	22.1	24.1
	pairs of compaired organic-conventional																												
	Average number of passes organic																												
	Average number of passes OeLN																												
			Sugar beet, OeLN intensive, wholesale	Sugar beet, OeLN, wholesale	Sugar beet, organic, wholesale	Fodder beet, OeLN intensive, wholesale	Fodder beet, OeLN, wholesale	Fodder beet, organic, wholesale	Tobacco, Burley, OeLN, air dried	Tobacco, Virgine, OeLN, air dried	Potatoes, OeLN intensive, wholesale	Potatoes, OeLN, wholesale	Potatoes, organic, wholesale	Potatoes, OeLN intensive, retail	Potatoes, OeLN, retail	Potatoes, organic, retail	Processing potatoes, OeLN intensive, wholesale	Processing potatoes, OeLN, wholesale	Processing potatoes, organic, wholesale	Meadow, OeLN intensive	Meadow, OeLN	Meadow, organic	Meadow forage, OeLN intensive, sale	Meadow forage, OeLN, sale	Meadow forage, organic, sale	Machine beans, OeLN	Machine beans, organic	Threshing peas, OeLN	Threshing peas, organic
			15	14	11.2	14	14	10.2	16	16	25.2	23.2	20.2	25.2	23.2	20.2	25.2	23.2	20.2	24.7	23.6	22.6	31	30.9	30.4	22	22	22.1	24.1

english	unit	harvester, 150 kW (soybean, peas)	harvester, 90 kW (maize, CCM)	forage harvester, self-propelled, 4 rows	beet defoliator, 6 rows	beet harvester + conveyor belt	tobacco harvester, 2 rows, without lift (	potato haulm topper, 4 rows	potato harvester, 1 row	motor-mowers, 1.9m	rotary mower, 2.1-2.6m	mower and mower conditioner, 3m	rakes/tedder, 6.1-7.5 m	hay merger, 5.5-6.5m	flail mower, 2-2.5m	loader waggon, >20 m3/5 t FS	round baler	cultivator with roller, 3m	transport off the field and conditioning	planter, 3 rows, fast	trailed row hoe, 3 rows	trailed row hoe, 4 rows	rotary hoe, 5 rows 50cm	mechanical weeding, finger weeder, 5 ro	disc spreader, 450l	disc spreader, 450l	trailed muck spreader, hydraulic, 3t	manure tanker vacuum, 4m3	irrigation with tractor pump, 100m irrig	mounted sprayer, 12m	spreader for slug pellets	flame weeder mounted, 3m, 4 rows	trailer for distributing empty boxes
german	unit	Mähdrescher, 150 kW (Soja, Erbsen)	Mähdrescher, 90 kW (Mais, CCM)	Silohäcksler selbstfahrend 4-reihig	Köpfroder 6-reihig	Futterrübenernter + Überladeband	Tabakernter 2-reihig, ohne Lift (12Pers)	Kartoffelkrautschläger, 4-reihig	Kartoffelvollernter, 1-reihig, Rollboden	Motormäher, 1.9 m	Kreiselmäher, 2.1-2.6 m	Frontkreiselmäher + Heckaufbereiter 3m	Kreiselheuer, 6.1-7.5 m	Doppelschwader Mitenabl 5.5-6.5 m	Schlegelmulchgerät, 2-2.5 m	Futterernte Ladewagen, >20 m3/5 t FS	Rundballenpresse mittel, Netzbindung	Grubber mit Nachläufer, 3 m	Abtransport vom Feld und Aufbereitung	Setzmaschine, 3-reihig, schnell	Hacken/Häufeln, 3-reihig, mittel	Hacken/Häufeln, 4-reihig, mittel	Reihenhackfräse, 5-reihig 50 cm	Hackbürste, 5-reihig	Grunddüngung, Schleuderstreuer, 450 l	Kopfdüngung, Schleuderstreuer, 450 l	Misten, Hydrauliklader, 3 t-Zetter, pro t	Güllen, 4 m3-Vakuumfass, pro m3	Bewässern mit Traktorpumpe, 100 m Rohr	Feldspritze, 12 m	Körnerstreuer (Schnecken)	Abflammen mit Traktor, 3 m, 4-reihig	Leeres Gebinde verteilen
Source/comments		151 kW / 205 PS	151 kW / 205 PS		Terra Dos T4-40								GF 6502	655 SD Classic																			
With tractor?	x/o	o	o	o	x	x		x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Working width	m	6	6	3.1	2.82	1	1.6	1.3	0.32	1.9	2.35	3	6.8	6	2.25	6	6	3	50	1.5	1.5	2	2.5	2.5	10	10	6	10	56	12	10	3	10
Extra driving	[-]	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	2.5	2.5	1.3	1.3	1.3	1.3	1.3	1.3	2.5	2.5	1.3	1.3	1.3	1.3	1.3
Weight tractor front	kg	11000	11000	10000	1500	1500	1500	1600	1500	5200	5200	5200	1500	1500	2000	1500	1500	2000	1500	1500	2000	2000	2000	2000	1600	1600	1500	1500	3200	1600	1600	1600	1500
Weight tractor back	kg	3000	3000	3000	7200	7200	7200	5800	7200	4400	4400	4400	5400	5400	3200	7200	7200	3200	6200	5400	3200	3200	3200	3200	5800	5800	6400	7200	4400	5800	5800	5800	5400
Inflation pressure, front	kPa	161	161	111	25	25	25	29	25	64	64	64	28	28	33	25	25	33	25	28	33	33	33	33	29	29	28	25	57	29	29	29	28
Inflation pressure, back	kPa	47	47	51	40	40	40	73	40	66	66	66	76	76	46	40	40	46	48	76	46	46	46	46	73	73	73	40	64	73	73	73	76
Weight trailer full	kg	0	0	0	8000	8000	8000	0	8000	0	0	0	2000	2000	0	10000	10000	0	6000	2000	0	0	0	0	0	0	3000	8000	0	0	0	0	4000
Weight trailer empty	kg	0	0	0	5500	5500	5500	0	5500	0	0	0	2000	2000	0	3400	3400	0	1500	1000	0	0	0	0	0	0	1000	2500	0	0	0	0	1500
Inflation pressure, trailer	kPa	0	0	0	56	56	56	0	56	0	0	0	23	23	0	121	121	0	77	23	0	0	0	0	0	0	54	102	0	0	0	0	51
Number of trailer axes	[-]	0	0	0	1	1	1	0	1	0	0	0	1	1	0	1	1	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	1
Weight transmission to tractor, trailer full	kg	0	0	0	3000	3000	3000	1000	3000	0	1000	1000	1000	1000	1000	3000	3000	1000	2000	1000	1000	1000	1000	1000	1500	1500	2000	4000	0	2000	1500	1000	2000
Weight transmission to tractor, trailer emp	kg	0	0	0	2062.5	2063	2063	1000	2063	0	1000	1000	1000	1000	1000	1020	1020	1000	500	500	1000	1000	1000	1000	1000	1000	667	1250	0	1000	1000	1000	750

english	unit	4-mouldboard plough	disc spreader, 1000l	trailed muck spreader, hydraulic, 7t	precision seed drills, 3m	mounted sprayer, 15m	tined weeder, 9m, hydraulic	disc spreader, 1000l	manure tanker with row crop injector, 6	harvester, 150 kW (cereal, beans)	10 t tandem-axle tipping trailers, hydrau	square baler big	bale lifter/grab/stacker & bale trailer	cultivator, 3m	power harrow, 3m	2-mouldboard plough	cultivator, 2.5m	seedbed cultivators, 3m with roller	roller, 3m	trailed overseeder with roller, 3m	potato planter, 4 rows	seed driller, 4 rows, 3m	seed driller, 6 rows, 3m	tobacco planter	mounted seeder, 3m	seed driller, 5 rows	planter, 2 rows	planter, 3 rows, middle	tined weeder, 6m	Maize cultivator, 4 rows, 3m, 2 pers.	beet row hoe, 6 rows, 3m, 2 pers	row crop cultivator, 4 rows	trailed row hoe, 2 rows
german	unit	4-Schar-Pflug	Grunddüngung, Schleuderstreuer, 1000 l	Misten, Hydrauliklader, 7 t-Zetter, pro t	Bestellkombination, 3 m	Feldspritze, 15 m	Hackstriegel, 9 m hydraulisch	Kopfdüngung, Schleuderstreuer, 1000 l	Güllen, Schleppschlauch 6 m3-Pumpf. ; pro m3	Mähdrescher, 150kW (Getreide, Ackerbohnen)	10 t-Tandemkipper hydr., 2-Achs	Quaderballenpresse gross	Stroh, Heu laden + einführen, Grossballen	Nachbearbeitung, Grubber, 3 m	Kreiselegge, 3 m	2-Schar-Pflug	Bodenfräse, 2.5 m	Federzinkenegge, 3 m mit Krümler	Rauwalze, 3 m	Grassämaschine mit Walze, 3 m	Kartoffellegeautomat, 4-reihig	Einzelkornsämaschine, 4-reihig, 3 m	Einzelkornsämaschine, 6-reihig, 3 m	Tabaksetzmaschine	Sämaschine, 3 m	Einzelkornsämaschine, 5-reihig	Setzmaschine, 2-reihig	Setzmaschine, 3-reihig, mittel	Hackstriegel, 6 m	Maisscharhackgerät, 4-reihig, 3 m, 2 Pers.	Rübenscharhackgerät, 6-reihig, 3 m, 2 Pers.	Kartoffelhack- und häufelgerät, 4-reihig	Hacken/Häufeln, 2-reihig, mittel
Source/comments										151 kW / 205 PS		2m3/Qb; Heu 380 kg/Qb; Stroh 300kg/Qb			DC-CL-3000	VariOpal 5N 100																	
With tractor?	x/o	x	x	x	x	x	x	x	x	o	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Working width	m	1.6	20	7	3	15	9	20	10	6	50	6	6	3	3	0.75	2.5	3	3	3	1.3	3	3	1.2	3	3	1	1.5	6	3	3	1.3	1.2
Extra driving	[-]	1.3	1.3	2.5	1.3	1.3	1.3	1.3	2.5	1.3	2.5	1.3	2.5	1.3	1.3	1.3	1.3	1.3	1.3	1.3	2.5	1.3	1.3	2.5	1.3	1.3	2.5	2.5	1.3	1.3	1.3	1.3	1.3
Weight tractor front	kg	2000	1600	1500	1600	1600	2000	1600	1500	11000	2000	1500	2000	2000	2000	2000	2000	2000	2000	1600	1500	1600	1600	1500	1600	1600	1500	1500	2000	2000	2000	2000	2000
Weight tractor back	kg	3200	5800	7200	6600	5800	3200	5800	7200	3000	3200	7200	3200	3200	3200	3200	3200	3200	3200	6600	5400	6600	6600	5400	6600	6600	5400	5400	3200	3200	3200	3200	3200
Inflation pressure, front	kPa	33	29	25	27	29	33	29	25	161	33	25	33	33	33	33	33	33	33	27	28	27	27	28	27	27	28	28	33	33	33	33	33
Inflation pressure, back	kPa	46	73	40	46	73	46	73	40	47	46	40	46	46	46	46	46	46	46	46	76	46	46	76	46	46	76	76	46	46	46	46	46
Weight trailer full	kg	0	0	7000	0	0	0	0	8000	0	10000	10000	10000	0	0	0	0	0	0	0	2000	0	0	2000	0	0	2000	2000	0	0	0	0	0
Weight trailer empty	kg	0	0	2000	0	0	0	0	2500	0	2200	3400	2200	0	0	0	0	0	0	0	1000	0	0	1000	0	0	1000	1000	0	0	0	0	0
Inflation pressure, trailer	kPa	0	0	128	0	0	0	0	102	0	123	121	123	0	0	0	0	0	0	0	23	0	0	23	0	0	23	23	0	0	0	0	0
Number of trailer axes	[-]	0	0	1	0	0	0	0	1	0	2	1	2	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	0	0
Weight transmission to tractor, trailer full	kg	1000	2000	3000	2000	2000	1000	2000	3000	0	0	3000	0	1000	1000	1000	1000	1000	1000	2000	1000	2000	2000	1000	2000	2000	1000	1000	1000	1000	1000	1000	1000
Weight transmission to tractor, trailer emp	kg	1000	1000	857	1000	1000	1000	1000	937.5	0	0	1020	0	1000	1000	1000	1000	1000	1000	1000	500	1000	1000	500	1000	1000	500	500	1000	1000	1000	1000	1000

english	unit	harvestor	carrot harvester	beetroot harvester	celery harvestor	vegetable harvostor (brussel sprouts)	tillage after harvest or before harvest du	conveyor belt	levelling blade for tractors	chopper equipment	Maize cultivator, 4 rows, 3m	beet row hoe, 6 rows, 3m	3t agricultural trailer, 2 axles	8t agricultural trailer, 2 axles	tractor (diverse tractor hours)	plastic mulch roller and unroller	trailed muck spreader for orachards, 3m
german	unit	Ausfahren mit Schüttelroder	Karottenvollernter	Randenvollernter	Sellerievollernter	Rosenkohlvollernter	Unterfahren mit Messer	Querförderband	Planierschild zu Traktor	Abfräsen von Kraut und Strünken	Maissternhackgerät, 4-reihig, 3 m	Rübensternhackgerät, 6-reihig, 3 m	3 t-Pneuwagen, 2-Achs	8 t-Pneuwagen, 2-Achs	Diverse Zugkraftstunden	Vlies verlegen und aufrollen	Kompoststreuer für Obstanlagen, 3 m3
Source/comments																	
With tractor?	x/o	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Working width	m	1	1	1	1	1	1	1	1.2	2	3	3	50	50	50	1.5	3.5
Extra driving	[-]	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	2.5	2.5	1.3	1.3	2.5
Weight tractor front	kg	1500	1500	1500	1500	1500	1500	1500	1500	1600	2000	2000	2000	2000	1500	2000	1500
Weight tractor back	kg	7200	7200	7200	7200	7200	7200	7200	7200	5800	3200	3200	3200	3200	5400	3200	6400
Inflation pressure, front	kPa	25	25	25	25	25	25	25	25	29	33	33	33	33	28	33	28
Inflation pressure, back	kPa	40	40	40	40	40	40	40	40	73	46	46	46	46	76	46	73
Weight trailer full	kg	8000	8000	8000	8000	8000	8000	8000	8000	0	0	0	5200	10000	4000	5200	3000
Weight trailer empty	kg	5500	5500	5500	5500	5500	5500	5500	5500	0	0	0	1500	2200	1500	1500	1000
Inflation pressure, trailer	kPa	56	56	56	56	56	56	56	56	0	0	0	66	123	51	66	54
Number of trailer axes	[-]	1	1	1	1	1	1	1	1	0	0	0	2	2	1	2	1
Weight transmission to tractor, trailer full	kg	3000	3000	3000	3000	3000	3000	3000	3000	1000	1000	1000	0	0	2000	0	2000
Weight transmission to tractor, trailer emp	kg	2063	2063	2063	2063	2063	2063	2063	2063	1000	1000	1000	0	0	750	0	667

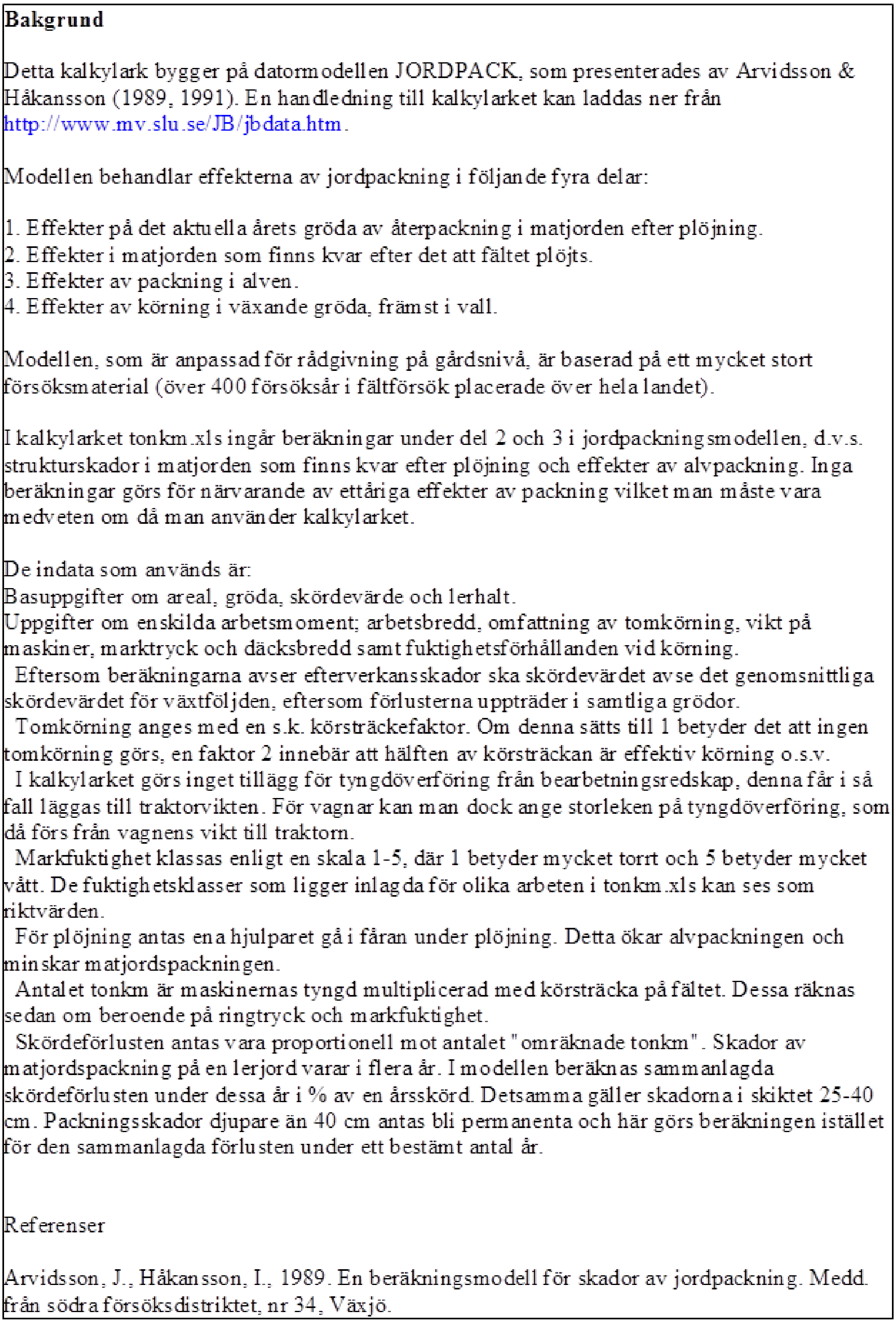
english	unit	trailed sprayer, 1000l	mounted chopper, 2.8m	mounted sprayer, folding arms, 400l	tractor-mounted tree shaker	hydraulic lift, self-propelled, by electricit	trailer for 4 pallet boxes (PALOXE)	maintenance of ecological compensatio	bedformer	trailed sprayer, 500l	5t agricultural trailer, 2 axles	distributing straw with agricultural traile	spading machine	flail mower	mounted sprayer, 200-300l	self-propelled sprayer, 8 kW	distributing wood chips, levelling
german	unit	Anhängegebläsespritze, 1000 l	Mulchgerät mit Schwenkarm, 2.8 m	Herbizidfass 400 l mit Balken beidseitig	Baumschüttler, hydraulisch, 3-Punkt	Hebebühne schwer, selbstfahrend, el.	Erntewagen für 4 Grosskisten	Pflege Wildkrautstreifen (Schnitt, Erneuern)	Dammformer für Beeren	Anbaugebläsespritze, 500 l	5 t-Pneuwagen, 2-Achs	Stroheinlage mit Pneuwagen, 5 t	Spatenmaschine	Schlegelmulchgerät, Dreipunktanbau	Gebläsespritze, 200-300 l, Dreipunktanbau	Sprühgerät, selbstfahrend, 8 kW	Schnitzel verteilen, ausebnen
Source/comments																	
With tractor?	x/o	x	x	x	x	o	x	x	x	x	x	x	x	x	x	o	x
Working width	m	3.5	2.8	3.5	3.5	3.5	3.5	3	2	15	50	1.5	2	2	15	15	1.5
Extra driving	[-]	1.3	1.3	1.3	1.3	1.3	2.5	0.3	1.3	1.3	2.5	1.3	1.3	1.3	1.3	1.3	1.3
Weight tractor front	kg	1600	2000	1600	1600	2000	2000	5200	2000	1600	2000	2000	1500	2000	1600	6000	2000
Weight tractor back	kg	5800	3200	5800	5800	2400	3200	4400	3200	5800	3200	3200	7200	3200	5800	6000	3200
Inflation pressure, front	kPa	29	33	29	29	44	33	64	33	29	33	33	25	33	29	121	33
Inflation pressure, back	kPa	73	46	73	73	48	46	66	46	73	46	46	40	46	73	121	46
Weight trailer full	kg	0	0	0	0	0	5200	0	0	0	5200	5200	8000	0	0	0	5200
Weight trailer empty	kg	0	0	0	0	0	1500	0	0	0	1500	1500	5500	0	0	0	1500
Inflation pressure, trailer	kPa	0	0	0	0	0	66	0	0	0	66	66	56	0	0	0	66
Number of trailer axes	[-]	0	0	0	0	0	2	0	0	0	2	2	1	0	0	0	2
Weight transmission to tractor, trailer full	kg	2000	1000	1500	1000	1500	0	1000	1000	1500	0	0	3000	1000	1500	0	0
Weight transmission to tractor, trailer emp	kg	1000	1000	1000	1000	1000	0	1000	1000	1000	0	0	2063	1000	1000	0	0

		Tractor	Trailer	Front tyre tractor	Back tyre tractor	Tyre trailer
tillage english	**tillage deutsch**					
2-mouldboard plough	2-Schar-Pflug	normal tractor	This equipment is ton trated as realer trailers with high axle load.	18.4R38 (146=Lastindex, Michelin Agribib)	600/65R38 (157)	
4-mouldboard plough	4-Schar-Pflug					
cultivator, 2.5m	Bodenfräse, 2.5 m					
bedformer	Dammformer für Beeren					
mechanical weeding, finger weeder, 5 rows	Hackbürste, 5-reihig					
trailed row hoe, 2 rows	Hacken/Häufeln, 2-reihig, mittel					
trailed row hoe, 3 rows	Hacken/Häufeln, 3-reihig, mittel					
trailed row hoe, 4 rows	Hacken/Häufeln, 4-reihig, mittel					
tined weeder, 6m	Hackstriegel, 6 m					
tined weeder, 9m, hydraulic	Hackstriegel, 9 m hydraulisch					
row crop cultivator, 4 rows	Kartoffelhack- und häufelgerät, 4-reihig					
power harrow, 3m	Kreiselegge, 3 m					
beet row hoe, 6 rows, 3m, 2 pers	Rübenscharhackgerät, 6-reihig, 3 m, 2 Pers.					
beet row hoe, 6 rows, 3m	Rübensternhackgerät, 6-reihig, 3 m					
roller, 3m	Rauwalze, 3 m					
rotary hoe, 5 rows 50cm	Reihenhackfräse, 5-reihig 50 cm					
Maize cultivator, 4 rows, 3m, 2 pers.	Maisscharhackgerät, 4-reihig, 3 m, 2 Pers.					
Maize cultivator, 4 rows, 3m	Maissternhackgerät, 4-reihig, 3 m					
cultivator with roller, 3m	Grubber mit Nachläufer, 3 m					
seedbed cultivators, 3m with roller	Federzinkenegge, 3 m mit Krümler					
flail mower, 2-2.5m	Schlegelmulchgerät, 2-2.5 m					
flail mower	Schlegelmulchgerät, Dreipunktanbau					
cultivator, 3m	Nachbearbeitung, Grubber, 3 m					
mounted chopper, 2.8m	Mulchgerät mit Schwenkarm, 2.8 m					
Seeding/planting english	**Seeding/planting deutsch**					
precision seed drills, 3m	Bestellkombination, 3 m	normal tractor (8200 kg)	Düngerstreuer simuliert in Terranimo die Sämaschine	18.4R38 (146=Lastindex)	600/65R38 (157)	
seed driller, 4 rows, 3m	Einzelkornsämaschine, 4-reihig, 3 m	normal tractor (8200 kg)	Düngerstreuer simuliert in Terranimo die Sämaschine	18.4R38 (146=Lastindex)	600/65R38 (157)	
seed driller, 5 rows	Einzelkornsämaschine, 5-reihig	normal tractor (8200 kg)	Düngerstreuer simuliert in Terranimo die Sämaschine	18.4R38 (146=Lastindex)	600/65R38 (157)	
seed driller, 6 rows, 3m	Einzelkornsämaschine, 6-reihig, 3 m	normal tractor (8200 kg)	Düngerstreuer simuliert in Terranimo die Sämaschine	18.4R38 (146=Lastindex)	600/65R38 (157)	
trailed overseeder with roller, 3m	Grassämaschine mit Walze, 3 m	normal tractor (8200 kg)	Düngerstreuer simuliert in Terranimo die Sämaschine	18.4R38 (146=Lastindex)	600/65R38 (157)	
planter, 2 rows	Setzmaschine, 2-reihig	small tractor 6900	1AchsAnhänger (Tandemachse) 2000 kg	420/85R34 (142, Michelin, Agribib)	540/65R34 (145, Trelleborg, TM800)	260/70-15.3 (122, Vredestein, Flotation+)
planter, 3 rows, middle	Setzmaschine, 3-reihig, mittel	small tractor 6900	1AchsAnhänger (Tandemachse) 2000 kg	420/85R34 (142, Michelin, Agribib)	540/65R34 (145, Trelleborg, TM800)	260/70-15.3 (122, Vredestein, Flotation+)
planter, 3 rows, fast	Setzmaschine, 3-reihig, schnell	small tractor 6900	1AchsAnhänger (Tandemachse) 2000 kg	420/85R34 (142, Michelin, Agribib)	540/65R34 (145, Trelleborg, TM800)	260/70-15.3 (122, Vredestein, Flotation+)
tobacco planter	Tabaksetzmaschine	small tractor 6900	1AchsAnhänger (Tandemachse) 2000 kg	420/85R34 (142, Michelin, Agribib)	540/65R34 (145, Trelleborg, TM800)	260/70-15.3 (122, Vredestein, Flotation+)
mounted seeder, 3m	Sämaschine, 3 m	normal tractor (8200 kg)	Düngerstreuer simuliert in Terranimo die Sämaschine	18.4R38 (146=Lastindex)	600/65R38 (157)	
potato planter, 4 rows	Kartoffellegeautomat, 4-reihig	small tractor 6900	1AchsAnhänger (Tandemachse) 2000 kg	420/85R34 (142, Michelin, Agribib)	540/65R34 (145, Trelleborg, TM800)	260/70-15.3 (122, Vredestein, Flotation+)
Fertilization english	**Fertilization deutsch**					
disc spreader, 1000l	Grunddüngung, Schleuderstreuer, 1000 l	small tractor 7400 kg		420/85R34 (142)	540/65R34 (145)	
disc spreader, 450l	Grunddüngung, Schleuderstreuer, 450 l	small tractor 7400 kg		420/85R34 (142)	540/65R34 (145)	
manure tanker vacuum, 4m3	Güllen, 4 m3-Vakuumfass, pro m3	normal tractor (8700 kg)	Güllefass 1-Achs (8000 kg)	18.4R38 (146=Lastindex)	600/65R38 (157)	650/65R30.5 (176)
manure tanker with row crop injector, 6m3	Güllen, Schleppschlauch 6 m3-Pumpf. ; pro m3	normal tractor (8700 kg)	Güllefass 1-Achs (8000 kg)	18.4R38 (146=Lastindex)	600/65R38 (157)	650/65R30.5 (176)
trailed muck spreader, hydraulic, 3t	Misten, Hydrauliklader, 3 t-Zetter, pro t	small tractor 7400 kg	Mistzetter 3 t	420/85R34 (142)	540/65R34 (145)	500/50-20 (149 Alliance)
trailed muck spreader, hydraulic, 7t	Misten, Hydrauliklader, 7 t-Zetter, pro t	normal tractor (8700 kg)	Mistzetter 7 t	18.4R38 (146=Lastindex)	600/65R38 (157)	500/50-20 (149 Alliance)
trailed muck spreader for orachards, 3m3	Kompoststreuer für Obstanlagen, 3 m3	small tractor 7400 kg	Mistzetter 3 t	420/85R34 (142)	540/65R34 (145)	500/50-20 (149 Alliance)
disc spreader, 1000l	Kopfdüngung, Schleuderstreuer, 1000 l	small tractor 7400 kg		420/85R34 (142)	540/65R34 (145)	
disc spreader, 450l	Kopfdüngung, Schleuderstreuer, 450 l	small tractor 7400 kg		420/85R34 (142)	540/65R34 (145)	
irrigation with tractor pump, 100m irrigation pipe	Bewässern mit Traktorpumpe, 100 m Rohr	normal tractor 7600 kg	Anhänger vernachlässigt	18.4R38 (146=Lastindex)	600/65R38 (157)	
Plant protection english	**Plant protection deutsch**					
trailed sprayer, 500l	Anbaugebläsespritze, 500 l	small tractor 7400 kg		420/85R34 (142)	540/65R34 (145)	

		Tractor	Trailer	Front tyre tractor	Back tyre tractor	Tyre trailer
trailed sprayer, 1000l	Anhängegebläsespritze, 1000 l	small tractor 7400 kg		420/85R34 (142)	540/65R34 (145)	
mounted sprayer, folding arms, 400l	Herbizidfass 400 l mit Balken beidseitig	small tractor 7400 kg		420/85R34 (142)	540/65R34 (145)	
mounted sprayer, 12m	Feldspritze, 12 m	small tractor 7400 kg		420/85R34 (142)	540/65R34 (145)	
mounted sprayer, 15m	Feldspritze, 15 m	small tractor 7400 kg		420/85R34 (142)	540/65R34 (145)	
flame weeder mounted, 3m, 4 rows	Abflammen mit Traktor, 3 m, 4-reihig	small tractor 7400 kg		420/85R34 (142)	540/65R34 (145)	
chopper equipment	Abfräsen von Kraut und Strünken	small tractor 7400 kg		420/85R34 (142)	540/65R34 (145)	
spreader for slug pellets	Körnerstreuer (Schnecken)	small tractor 7400 kg		420/85R34 (142)	540/65R34 (145)	
plastic mulch roller and unroller	Vlies verlegen und aufrollen	small tractor 5200 kg	2AchsAnhänger 5200 kg	18.4R38 (146=Lastindex, Michelin Agribib)	600/65R38 (157)	480/45-17 (146, Vredestein, Flotation+)
distributing wood chips, levelling	Schnitzel verteilen, ausebnen	small tractor 5200 kg	2AchsAnhänger 5200 kg	18.4R38 (146=Lastindex, Michelin Agribib)	600/65R38 (157)	480/45-17 (146, Vredestein, Flotation+)
distributing straw with agricultural trailer, 5t	Stroheinlage mit Pneuwagen, 5 t	small tractor 5200 kg	2AchsAnhänger 5200 kg	18.4R38 (146=Lastindex, Michelin Agribib)	600/65R38 (157)	480/45-17 (146, Vredestein, Flotation+)
self-propelled sprayer, 8 kW	Sprühgerät, selbstfahrend, 8 kW	self-propelled		320/90R50 (150)	320/90R50 (150)	
potato haulm topper, 4 rows	Kartoffelkrautschläger, 4-reihig	small tractor 7400 kg		420/85R34 (142)	540/65R34 (145)	
mounted sprayer, 200-300l	Gebläsespritze, 200-300 l, Dreipunktanbau	small tractor 7400 kg		420/85R34 (142)	540/65R34 (145)	
Harvest english	**Harvest deutsch**					
loader waggon, >20 m3/5 t FS	Futterernte Ladewagen, >20 m3/5 t FS	normal tractor (8700 kg)	Grossballenpresse 10000 kg, 1-achsig	18.4R38 (146=Lastindex)	600/65R38 (157)	28L-26 (154)
round baler	Rundballenpresse mittel, Netzbindung	normal tractor (8700 kg)	Grossballenpresse 10000 kg, 1-achsig	18.4R38 (146=Lastindex)	600/65R38 (157)	28L-26 (154)
square baler big	Quaderballenpresse gross	normal tractor (8700 kg)	Grossballenpresse 10000 kg, 1-achsig	18.4R38 (146=Lastindex)	600/65R38 (157)	28L-26 (154)
harvester, 150 kW (soybean, peas)	Mähdrescher, 150 kW (Soja, Erbsen)	self-propelled		680/85R32 (178)	20.8R42 = 520/85R42 (162)	
harvester, 150 kW (cereal, beans)	Mähdrescher, 150kW (Getreide, Ackerbohnen)	self-propelled		680/85R32 (178)	20.8R42 = 520/85R42 (162)	
harvester, 90 kW (maize, CCM)	Mähdrescher, 90 kW (Mais, CCM)	self-propelled		680/85R32 (178)	20.8R42 = 520/85R42 (162)	
forage harvester, self-propelled, 4 rows	Silohäcksler selbstfahrend 4-reihig	self-propelled		650/75R32 (172)	650/75R32 (172)	
hay merger, 5.5-6.5m	Doppelschwader Mitenabl 5.5-6.5 m	small tractor 6900 kg	1AchsAnhänger (Tandemachse) 2000 kg	420/85R34 (142, Michelin, Agribib)	540/65R34 (145, Trelleborg, TM800)	260/70-15.3 (122, Vredestein, Flotation+)
mower and mower conditioner, 3m	Frontkreiselmäher + Heckaufbereiter 3m	small tractor 5200 kg		18.4R38 (146=Lastindex, Michelin Agribib)	600/65R38 (157)	
rakes/tedder, 6.1-7.5 m	Kreiselheuer, 6.1-7.5 m	small tractor 6900 kg	1AchsAnhänger (Tandemachse) 2000 kg	420/85R34 (142, Michelin, Agribib)	540/65R34 (145, Trelleborg, TM800)	260/70-15.3 (122, Vredestein, Flotation+)
rotary mower, 2.1-2.6m	Kreiselmäher, 2.1-2.6 m	small tractor 5200 kg		18.4R38 (146=Lastindex, Michelin Agribib)	600/65R38 (157)	
motor-mowers, 1.9m	Motormäher, 1.9 m	small tractor 5200 kg		18.4R38 (146=Lastindex, Michelin Agribib)	600/65R38 (157)	
maintenance of ecological compensation area (cutting, renewing)	Pflege Wildkrautstreifen (Schnitt, Erneuern)	small tractor 5200 kg		18.4R38 (146=Lastindex, Michelin Agribib)	600/65R38 (157)	
hydraulic lift, self-propelled, by electricity	Hebebühne schwer, selbstfahrend, el.	small tractor	Der Traktor steht stellvertretend für die Hebebühne: http://www.bermartec.com/technischedaten.html	26 * 12.00 / 12“ (Alliance I-312, 94)	26 * 12.00 / 12“ (Alliance I-312, 94)	
tractor-mounted tree shaker	Baumschüttler, hydraulisch, 3-Punkt	small tractor 7400 kg		420/85R34 (142)	540/65R34 (145)	
tillage after harvest or before harvest due to bad yield (horticulture	Unterfahren mit Messer	normal tractor (8700 kg)	Vollernter gezogen 1-reihig (Bunker 2000 kg), dargestellt in Terranimo durch Güllefass (8000 kg)	18.4R38 (146=Lastindex)	600/65R38 (157)	16.0/70-20 (Vredestein, Flotation+)
tobacco harvester, 2 rows, without lift (12 pers.)	Tabakernter 2-reihig, ohne Lift (12Pers)	normal tractor (8700 kg)	Vollernter gezogen 1-reihig (Bunker 2000 kg), dargestellt in Terranimo durch Güllefass (8000 kg)	18.4R38 (146=Lastindex)	600/65R38 (157)	16.0/70-20 (Vredestein, Flotation+)
celery harvestor	Sellerievollernter	normal tractor (8700 kg)	Vollernter gezogen 1-reihig (Bunker 2000 kg), dargestellt in Terranimo durch Güllefass (8000 kg)	18.4R38 (146=Lastindex)	600/65R38 (157)	16.0/70-20 (Vredestein, Flotation+)
conveyor belt	Querförderband	normal tractor (8700 kg)	Vollernter gezogen 1-reihig (Bunker 2000 kg), dargestellt in Terranimo durch Güllefass (8000 kg)	18.4R38 (146=Lastindex)	600/65R38 (157)	16.0/70-20 (Vredestein, Flotation+)
beetroot harvester	Randenvollernter	normal tractor (8700 kg)	Vollernter gezogen 1-reihig (Bunker 2000 kg), dargestellt in Terranimo durch Güllefass (8000 kg)	18.4R38 (146=Lastindex)	600/65R38 (157)	16.0/70-20 (Vredestein, Flotation+)
vegetable harvostor (brussel sprouts)	Rosenkohlvollernter	normal tractor (8700 kg)	Vollernter gezogen 1-reihig (Bunker 2000 kg), dargestellt in Terranimo durch Güllefass (8000 kg)	18.4R38 (146=Lastindex)	600/65R38 (157)	16.0/70-20 (Vredestein, Flotation+)
potato harvester, 1 row	Kartoffelvollernter, 1-reihig, Rollboden	normal tractor (8700 kg)	Vollernter gezogen 1-reihig (Bunker 20	18.4R38 (146=Lastindex)	600/65R38 (157)	16.0/70-20 (Vredestein, Flotation+)
carrot harvester	Karottenvollernter	normal tractor (8700 kg)	Vollernter gezogen 1-reihig (Bunker 2000 kg), dargestellt in Terranimo durch Güllefass (8000 kg)	18.4R38 (146=Lastindex)	600/65R38 (157)	16.0/70-20 (Vredestein, Flotation+)
beet defoliator, 6 rows	Köpfroder 6-reihig	normal tractor (8700 kg)	Vollernter gezogen 1-reihig (Bunker 2000 kg), dargestellt in Terranimo durch Güllefass (8000 kg)	18.4R38 (146=Lastindex)	600/65R38 (157)	16.0/70-20 (Vredestein, Flotation+)
beet harvester + conveyor belt	Futterrübenernter + Überladeband	normal tractor (8700 kg)	Zuckerrübenernte gezogen 2reihig	18.4R38 (146=Lastindex)	600/65R38 (157)	16.0/70-20 (Vredestein, Flotation+)
harvestor	Ausfahren mit Schüttelroder	normal tractor (8700 kg)	Vollernter gezogen 1-reihig (Bunker 2000 kg), dargestellt in Terranimo durch Güllefass (8000 kg)	18.4R38 (146=Lastindex)	600/65R38 (157)	16.0/70-20 (Vredestein, Flotation+)
spading machine	Spatenmaschine	normal tractor (8700 kg)	Vollernter gezogen 1-reihig (Bunker 2000 kg), dargestellt in Terranimo durch Güllefass (8000 kg)	18.4R38 (146=Lastindex)	600/65R38 (157)	16.0/70-20 (Vredestein, Flotation+)
levelling blade for tractors	Planierschild zu Traktor	normal tractor (8700 kg)	Vollernter gezogen 1-reihig (Bunker 2000 kg), dargestellt in Terranimo durch Güllefass (8000 kg)	18.4R38 (146=Lastindex)	600/65R38 (157)	16.0/70-20 (Vredestein, Flotation+)
Transport english	**Transport deutsch**					
10 t tandem-axle tipping trailers, hydraulic, 2 axles	10 t-Tandemkipper hydr., 2-Achs	small tractor 5200 kg	2AchsAnhänger 10000 kg	18.4R38 (146=Lastindex, Michelin Agribib)	600/65R38 (157)	480/45-17 (146, Vredestein, Flotation+)
3t agricultural trailer, 2 axles	3 t-Pneuwagen, 2-Achs	small tractor 5200 kg	2AchsAnhänger 5200 kg	18.4R38 (146=Lastindex, Michelin Agribib)	600/65R38 (157)	480/45-17 (146, Vredestein, Flotation+)
5t agricultural trailer, 2 axles	5 t-Pneuwagen, 2-Achs	small tractor 5200 kg	2AchsAnhänger 5200 kg	18.4R38 (146=Lastindex, Michelin Agribib)	600/65R38 (157)	480/45-17 (146, Vredestein, Flotation+)
8t agricultural trailer, 2 axles	8 t-Pneuwagen, 2-Achs	small tractor 5200 kg	2AchsAnhänger 10000 kg	18.4R38 (146=Lastindex, Michelin Agribib)	600/65R38 (157)	480/45-17 (146, Vredestein, Flotation+)
transport off the field and conditioning	Abtransport vom Feld und Aufbereitung	normal tractor (7700 kg)	1AchsAnhänger (Tandemachse) 6000 kg	18.4R38 (146=Lastindex, Michelin Agribib)	600/65R38 (157)	480/45-17 (146, Vredestein, Flotation+)
trailer for distributing empty boxes	Leeres Gebinde verteilen	small tractor 6900 kg	1AchsAnhänger (Tandemachse) 4000 kg	420/85R34 (142, Michelin, Agribib)	540/65R34 (145, Trelleborg, TM800)	480/45-17 (146, Vredestein, Flotation+)
trailer for 4 pallet boxes (PALOXE)	Erntewagen für 4 Grosskisten	small tractor 5200 kg	2AchsAnhänger 5200 kg	18.4R38 (146=Lastindex, Michelin Agribib)	600/65R38 (157)	480/45-17 (146, Vredestein, Flotation+)
tractor (diverse tractor hours)	Diverse Zugkraftstunden	small tractor 6900 kg	1AchsAnhänger (Tandemachse) 4000 kg	420/85R34 (142, Michelin, Agribib)	540/65R34 (145, Trelleborg, TM800)	480/45-17 (146, Vredestein, Flotation+)
bale lifter/grab/stacker & bale trailer	Stroh, Heu laden + einführen, Grossballen	small tractor 5200 kg	2AchsAnhänger 10000 kg	18.4R38 (146=Lastindex, Michelin Agribib)	600/65R38 (157)	480/45-17 (146, Vredestein, Flotation+)

11.8 ORIGINAL AND ADAPTED MODEL

Tonkm- ett program för att räkna ut körintensitet och skördeförluster av jordpackning i ettåriga grödor



Bakgrund

Detta kalkylark bygger på datormodellen JORDPACK, som presenterades av Arvidsson & Håkansson (1989, 1991). En handledning till kalkylarket kan laddas ner från http://www.mv.slu.se/JB/jbdata.htm.

Modellen behandlar effekterna av jordpackning i följande fyra delar:

1. Effekter på det aktuella årets gröda av återpackning i matjorden efter plöjning.
2. Effekter i matjorden som finns kvar efter det att fältet plöjts.
3. Effekter av packning i alven.
4. Effekter av körning i växande gröda, främst i vall.

Modellen, som är anpassad för rådgivning på gårdsnivå, är baserad på ett mycket stort försöksmaterial (över 400 försöksår i fältförsök placerade över hela landet).

I kalkylarket tonkm.xls ingår beräkningar under del 2 och 3 i jordpackningsmodellen, d.v.s. strukturskador i matjorden som finns kvar efter plöjning och effekter av alvpackning. Inga beräkningar görs för närvarande av ettåriga effekter av packning vilket man måste vara medveten om då man använder kalkylarket.

De indata som används är:
Basuppgifter om areal, gröda, skördevärde och lerhalt.
Uppgifter om enskilda arbetsmoment; arbetsbredd, omfattning av tomkörning, vikt på maskiner, marktryck och däcksbredd samt fuktighetsförhållanden vid körning.

Eftersom beräkningarna avser efterverkansskador ska skördevärdet avse det genomsnittliga skördevärdet för växtföljden, eftersom förlusterna uppträder i samtliga grödor.

Tomkörning anges med en s.k. körsträckefaktor. Om denna sätts till 1 betyder det att ingen tomkörning görs, en faktor 2 innebär att hälften av körsträckan är effektiv körning o.s.v.

I kalkylarket görs inget tillägg för tyngdöverföring från bearbetningsredskap, denna får i så fall läggas till traktorvikten. För vagnar kan man dock ange storleken på tyngdöverföring, som då förs från vagnens vikt till traktorn.

Markfuktighet klassas enligt en skala 1-5, där 1 betyder mycket torrt och 5 betyder mycket vått. De fuktighetsklasser som ligger inlagda för olika arbeten i tonkm.xls kan ses som riktvärden.

För plöjning antas ena hjulparet gå i fåran under plöjning. Detta ökar alvpackningen och minskar matjordspackningen.

Antalet tonkm är maskinernas tyngd multiplicerad med körsträcka på fältet. Dessa räknas sedan om beroende på ringtryck och markfuktighet.

Skördeförlusten antas vara proportionell mot antalet "omräknade tonkm". Skador av matjordspackning på en lerjord varar i flera år. I modellen beräknas sammanlagda skördeförlusten under dessa år i % av en årsskörd. Detsamma gäller skadorna i skiktet 25-40 cm. Packningsskador djupare än 40 cm antas bli permanenta och här görs beräkningen istället för den sammanlagda förlusten under ett bestämt antal år.

Referenser

Arvidsson, J., Håkansson, I., 1989. En beräkningsmodell för skador av jordpackning. Medd. från södra försöksdistriktet, nr 34, Växjö.

Växtföljd	Utan vall		Skörd, kr/ha:	6000.0	Antal ha:	1.0						
Gröda	Vårrybs											
	Stubbearb.	Plöjning	Harvning	Sådd	H-gödsel	Vältning	Sprutning	Skörd	Rötr. flyt	Rötr. fast	Övrigt	Summa
Antal körningar	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Arbetsbredd	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Körsträckefaktor	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	2.5	2.5	1.3	
Lerhalt	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	
Vattenhalt matjord	3.3	3.6	3.6	3.5	3.5	3.4	3.0	3.0	3.5	3.5	3.0	
Vattenhalt alv	3.0	3.0	4.0	4.0	4.0	4.0	3.0	3.0	3.5	3.5	3.0	
Vikt traktor fram	2000.0	2000.0	2000.0	1800.0	1800.0	1800.0	1000.0	6300.0	2000.0	2000.0	0.0	
Vikt traktor bak	3200.0	3200.0	3200.0	2200.0	2200.0	2200.0	1820.0	1800.0	3200.0	3200.0	0.0	
Ringtryck fram	80.0	80.0	80.0	60.0	60.0	60.0	60.0	160.0	80.0	80.0	150.0	
Ringtryck bak	80.0	80.0	80.0	60.0	60.0	60.0	80.0	160.0	80.0	80.0	200.0	
Däcksbredd fram, cm	43.0	43.0	43.0	35.0	35.0	35.0	25.0	47.0	43.0	43.0	35.0	
Däcksbredd bak	53.0	53.0	53.0	45.0	45.0	45.0	43.0	32.0	53.0	53.0	45.0	
Vikt full vagn	0.0	0.0	0.0	1500.0	2500.0	0.0	2000.0	0.0	3800.0	15200.0	0.0	
Vikt tom vagn	0.0	0.0	0.0	3500.0	1500.0	0.0	1000.0	0.0	13800.0	3200.0	0.0	
Ringtryck	200.0	200.0	200.0	100.0	100.0	200.0	100.0	200.0	80.0	120.0	200.0	
Antal axlar	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	1.0	
Viktöverf. till traktor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1000.0	1000.0	0.0	
Matjord												
Framhjul, Mgkm	14.8	10.0	16.3	11.7	11.7	11.3	5.5	60.2	30.3	30.3	0.0	202.0
Bakhjul, Mgkm	23.7	16.0	26.0	14.3	14.3	13.8	12.2	17.2	63.7	63.7	0.0	264.8
Vagn, Mgkm	0.0	0.0	0.0	22.4	17.9	0.0	11.4	0.0	118.3	155.5	0.0	325.6
Totalt, Mgkm	38.5	26.0	42.3	48.4	43.9	25.1	29.1	77.3	212.3	249.5	0.0	792.4
Förlust, %	1.2	0.8	1.3	1.5	1.4	0.8	0.9	2.4	6.5	7.7	0.0	24.4
Förlust, kr	71.2	48.1	78.1	89.4	81.1	46.5	53.7	142.9	392.3	461.1	0.0	1464.4
25-40 cm												
Framhjul, Mgkm	0.0	4.5	0.0	0.0	0.0	0.0	0.0	16.3	0.0	0.0	0.0	20.8
Bakhjul, Mgkm	0.0	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2
Vagn, Mgkm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.3	58.7	0.0	99.0
Totalt, Mgkm	0.0	11.6	0.0	0.0	0.0	0.0	0.0	16.3	40.3	58.7	0.0	127.0
Förlust, %	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.4	1.0	1.5	0.0	3.2
Förlust, kr	0.0	17.5	0.0	0.0	0.0	0.0	0.0	24.5	60.4	88.1	0.0	190.4
>40 cm												
Framhjul, Mgkm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	2.1
Bakhjul, Mgkm	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Vagn, Mgkm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.6	0.0	40.6
Totalt, Mgkm	0.0	0.4	0.0	0.0	0.0	0.0	0.0	2.1	0.0	40.6	0.0	43.1
Förlust, promille/år	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	1.0	0.0	1.1
Förlust, kr/50 år	0.0	3.3	0.0	0.0	0.0	0.0	0.0	15.4	0.0	304.5	0.0	323.2
log ringtryck	1.9	1.9	1.9	1.8	1.8	1.8	1.8	2.2	1.9	1.9	2.2	#NUM!
	1.9	1.9	1.9	1.8	1.8	1.8	1.9	2.2	1.9	1.9	2.3	#NUM!
	2.3	2.3	2.3	2.0	2.0	2.3	2.0	2.3	1.9	2.1	2.3	#NUM!
omr 25-40	-0.9	-0.4	-1.8	-1.8	-1.8	-1.8	-1.2	1.3	-1.3	-1.3	-2.1	#NUM!
omr 25-40	-0.4	-0.2	-0.7	-1.5	-1.5	-1.5	-1.0	-1.2	-0.5	-0.5	-2.3	#NUM!
omr 25-40	-2.3	-2.3	-4.6	-2.4	-1.4	-4.6	-1.0	-2.3	-3.5	4.7	-2.3	#NUM!
omr 25-40	-2.3		-4.6	-0.5	-2.4	-4.6	-1.4	-2.3	3.2	-4.4	-2.3	
villkor>0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	#NUM!
villkor>0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	#NUM!
villkor>0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	#NUM!
villkor>0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	
omr >40 framhjul	-1.8	-1.8	-3.6	-3.4	-3.4	-3.4	-2.1	0.2	-2.7	-2.7	-3.1	#NUM!
	-1.2	-1.2	-2.5	-3.1	-3.1	-3.1	-1.9	-2.2	-1.9	-1.9	-3.3	#NUM!
	-3.3	-3.3	-6.6	-4.2	-3.3	-6.6	-1.9	-3.3	-6.1	1.6	-3.3	#NUM!
	-3.3		-6.6	-2.4	-4.2	-6.6	-2.4	-3.3	0.5	-7.2	-3.3	
villkor>0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	#NUM!
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	#NUM!
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	#NUM!
	0.0		0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	
		-0.4										
		0.1										
		0.0										
		1.0										

	Rotation	Without ley		Harvest, kr/ha:	6000.0	Number of ha:	1.0						
	Crop	Turnip rape											
		Stubble processing	Plowing	Harrowing	Sowing	Winter manure	Overturning/Rolli	Spraying	Harvesting	Liquid manure	Manure	Other	Sum
Antal körningar	Number of operations	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Arbetsbredd	Working width	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Körsträckefaktor	Extra driving	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	2.5	2.5	1.3	
Lerhalt	Clay content	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	
Vattenhalt matjord	Soil moisture class, topsoil	3.3	3.6	3.6	3.5	3.5	3.4	3.0	3.0	3.5	3.5	3.0	
Vattenhalt alv	Soil moisture class, subsoil	3.0	3.0	4.0	4.0	4.0	4.0	3.0	3.0	3.5	3.5	3.0	
Vikt traktor fram	Weight tractor front	2000.0	2000.0	2000.0	1800.0	1800.0	1800.0	1000.0	6300.0	2000.0	2000.0	0.0	
Vikt traktor bak	Weight tractor back	3200.0	3200.0	3200.0	2200.0	2200.0	2200.0	1820.0	1800.0	3200.0	3200.0	0.0	
Ringtryck fram	Inflation pressure, front	80.0	80.0	80.0	60.0	60.0	60.0	60.0	160.0	80.0	80.0	150.0	
Ringtryck bak	Inflation pressure, back	80.0	80.0	80.0	60.0	60.0	60.0	80.0	160.0	80.0	80.0	200.0	
Däcksbredd fram, cm	not needed	43.0	43.0	43.0	35.0	35.0	35.0	25.0	47.0	43.0	43.0	35.0	
Däcksbredd bak	not needed	53.0	53.0	53.0	45.0	45.0	45.0	43.0	32.0	53.0	53.0	45.0	
Vikt full vagn	Weight trailer full	0.0	0.0	0.0	1500.0	2500.0	0.0	2000.0	0.0	3800.0	15200.0	0.0	
Vikt tom vagn	Weight trailer empty	0.0	0.0	0.0	3500.0	1500.0	0.0	1000.0	0.0	13800.0	3200.0	0.0	
Ringtryck	Inflation pressure, trailer	200.0	200.0	200.0	100.0	100.0	200.0	100.0	200.0	80.0	120.0	200.0	
Antal axlar	Number of trailer axes	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	1.0	
Viktöverf. till traktor	Weight transmission to tractor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1000.0	1000.0	0.0	
Matjord	Top soil (0-25 cm)												
Framhjul, Mgkm	Tractor front, tkm	14.8	10.0	16.3	11.7	11.7	11.3	5.5	60.2	30.3	30.3	0.0	202.0
Bakhjul, Mgkm	Tractor back, tkm	23.7	16.0	26.0	14.3	14.3	13.8	12.2	17.2	63.7	63.7	0.0	264.8
Vagn, Mgkm	Trailer, tkm	0.0	0.0	0.0	22.4	17.9	0.0	11.4	0.0	118.3	155.5	0.0	325.6
Totalt, Mgkm	Total, tkm	38.5	26.0	42.3	48.4	43.9	25.1	29.1	77.3	212.3	249.5	0.0	792.4
Förlust, %	Yield loss, %	1.2	0.8	1.3	1.5	1.4	0.8	0.9	2.4	6.5	7.7	0.0	24.4
Förlust, kr	Value loss, $	71.2	48.1	78.1	89.4	81.1	46.5	53.7	142.9	392.3	461.1	0.0	1464.4
25-40 cm	Mid soil (25-40 cm)												
Framhjul, Mgkm	Tractor front, tkm	0.0	4.5	0.0	0.0	0.0	0.0	0.0	16.3	0.0	0.0	0.0	20.8
Bakhjul, Mgkm	Tractor back, tkm	0.0	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2
Vagn, Mgkm	Trailer, tkm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.3	58.7	0.0	99.0
Totalt, Mgkm	Total, tkm	0.0	11.6	0.0	0.0	0.0	0.0	0.0	16.3	40.3	58.7	0.0	127.0
Förlust, %	Yield loss, %	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.4	1.0	1.5	0.0	3.2
Förlust, kr	Value loss, $	0.0	17.5	0.0	0.0	0.0	0.0	0.0	24.5	60.4	88.1	0.0	190.4
>40 cm	Bottom soil (>40 cm)												
Framhjul, Mgkm	Tractor front, tkm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	2.1
Bakhjul, Mgkm	Tractor back, tkm	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Vagn, Mgkm	Trailer, tkm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.6	0.0	40.6
Totalt, Mgkm	Total, tkm	0.0	0.4	0.0	0.0	0.0	0.0	0.0	2.1	0.0	40.6	0.0	43.1
Förlust, promille/år	Yield loss, per mille/year	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	1.0	0.0	1.1
Förlust, kr/50 år	Value loss, $/50 years	0.0	3.3	0.0	0.0	0.0	0.0	0.0	15.4	0.0	304.5	0.0	323.2
log ringtryck	LOG Inflation pressure	1.9	1.9	1.9	1.8	1.8	1.8	1.8	2.2	1.9	1.9	2.2	#NUM!
		1.9	1.9	1.9	1.8	1.8	1.8	1.9	2.2	1.9	1.9	2.3	#NUM!
		2.3	2.3	2.3	2.0	2.0	2.3	2.0	2.3	1.9	2.1	2.3	#NUM!
omr 25-40		-0.9	-0.4	-1.8	-1.8	-1.8	-1.8	-1.2	1.3	-1.3	-1.3	-2.1	#NUM!
omr 25-40		-0.4	-0.2	-0.7	-1.5	-1.5	-1.5	-1.0	-1.2	-0.5	-0.5	-2.3	#NUM!
omr 25-40		-2.3	-2.3	-4.6	-2.4	-1.4	-4.6	-1.0	-2.3	-3.5	4.7	-2.3	#NUM!
omr 25-40		-2.3		-4.6	-0.5	-2.4	-4.6	-1.4	-2.3	3.2	-4.4	-2.3	
villkor>0	check if larger than 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	#NUM!
villkor>0	check if larger than 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	#NUM!
villkor>0	check if larger than 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	#NUM!
villkor>0	check if larger than 0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	
omr >40 framhjul		-1.8	-1.8	-3.6	-3.4	-3.4	-3.4	-2.1	0.2	-2.7	-2.7	-3.1	#NUM!
		-1.2	-1.2	-2.5	-3.1	-3.1	-3.1	-1.9	-2.2	-1.9	-1.9	-3.3	#NUM!
		-3.3	-3.3	-6.6	-4.2	-3.3	-6.6	-1.9	-3.3	-6.1	1.6	-3.3	#NUM!
		-3.3		-6.6	-2.4	-4.2	-6.6	-2.4	-3.3	0.5	-7.2	-3.3	
villkor>0	check if larger than 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	#NUM!
	check if larger than 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	#NUM!
	check if larger than 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	#NUM!
	check if larger than 0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	
			-0.4										
			0.1										
			0.0										
			1.0										

Bedingungen
Reifeninnendruck Anhänger B18>=1
Anzahl Achsen
B19>=1

Machines

		Factor	Weight	Distance		Factor	Weight	Distance		Tire pressure	Water	Passes	Condition 1	Condition 2
Top soil front			B10/1000	* 10*B6/B5						* Log10(B12)-1.2	* B8*0.2625-0.056	* B4		
Top soil back			(B11+B20)/1000	* 10*B6/B5						* Log10(B13)-1.2	* B8*0.2625-0.056	* B4		
Top soil trailer			(B16+B17-2*B20)/2/1000	* 10*B6/B5						* Log10(B18)-1.2	* B8*0.2625-0.056	* B4		
Mid soil front			(B10-4000)/1000	* 10*B6/B5						* Log10(B12)-0.53	* (B9-2)*0.326	* B4	Weight > 0	Water > 0
Mid soil back			(B11-4000)/1000	* 10*B6/B5						* Log10(B13)-0.53	* (B9-2)*0.326	* B4	Weight > 0	Water > 0
Mid soil trailer	(	0.5 *	((B16-B20)/B19-4000)/1000*B19	* 10*B6/B5	+	0.5 *	((B17-B20)/B19-4000)/1000*B19	* 10*B6/B5	)	* Log10(B18)-0.53	* (B9-2)*0.326	* B4	Weight > 0	Water > 0
Bottom soil front			(B10-6000)/1000	* 10*B6/B5						* Log10(B12)-0.27	* (B9-2)*0.272	* B4	Weight > 0	Water > 0
Bottom soil back			(B11-6000)/1000	* 10*B6/B5						* Log10(B13)-0.27	* (B9-2)*0.272	* B4	Weight > 0	Water > 0
Bottom soil trailer	(	0.5 *	((B16-B20)/B19-6000)/1000*B19	* 10*B6/B5	+	0.5 *	((B17-B20)/B19-6000)/1000*B19	* 10*B6/B5	)	* Log10(B18)-0.27	* (B9-2)*0.272	* B4	Weight > 0	Water > 0

Plows

		Factor	Weight	Distance		Factor	Weight	Distance		Tire pressure	Water	Passes	Condition 1	Condition 2
Top soil front			B10/1000	* 10*(B6-0.5)/B5						* Log10(B12)-1.2	* B8*0.2625-0.056	* B4		
Top soil back			(B11+B20)/1000	* 10*(B6-0.5)/B5						* Log10(B13)-1.2	* B8*0.2625-0.056	* B4		
Mid soil front	(	0.5 *	(B10-4000)/1000	* 10*B6/B5	+	0.5 *	B10/1000	* 10/B5	)	* Log10(B12)-0.53	* (B9-2)*0.326	* B4	Weight > 0	Water > 0
Mid soil back	(	0.5 *	(B11-4000)/1000	* 10*B6/B5	+	0.5 *	B11/1000	* 10/B5	)	* Log10(B13)-0.53	* (B9-2)*0.326	* B4	Weight > 0	Water > 0
Bottom soil front	(		(B10-6000)/1000	* 10*(B6-0.5)/B5	+		(B10-3000)/1000	* 10/B5*0.5	)	* Log10(B12)-0.27	* (B9-2)*0.272	* B4	Weight > 0	Water > 0
Bottom soil back	(		(B11-6000)/1000	* 10*(B6-0.5)/B5	+		(B11-3000)/1000	* 10/B5*0.5	)	* Log10(B13)-0.27	* (B9-2)*0.272	* B4	Weight > 0	Water > 0

cells that have been changed in adaptation

Cell code

B4	Number of operations
B5	Working width
B6	Extra driving
B7	Clay content
B8	Soil moisture class, topsoil
B9	Soil moisture class, subsoil
B10	Weight tractor front
B11	Weight tractor back
B12	Inflation pressure, front
B13	Inflation pressure, back
B14	not needed
B15	not needed
B16	Weight trailer full
B17	Weight trailer empty
B18	Inflation pressure, trailer
B19	Number of trailer axes
B20	Weight transmission to tractor

Bedingungen
Reifeninnendruck Anhänger B18>=1
Anzahl Achsen
B19>=1

Machines

		Factor		Weight		Distance		Factor		Weight		Distance			Tire pressure		Water		Passes	Condition 1	Condition 2
Top soil front				B10/1000	*	10*B6/B5								*	Log10(B12)-1.2	*	B8*0.2625-0.056	*	B4		
Top soil back				(B11+(B20+B21)/2)/1000	*	10*B6/B5								*	Log10(B13)-1.2	*	B8*0.2625-0.056	*	B4		
Top soil trailer				(B16+B17-2*B20)/2/1000	*	10*B6/B5								*	Log10(B18)-1.2	*	B8*0.2625-0.056	*	B4		
Mid soil front				(B10-4000)/1000	*	10*B6/B5								*	Log10(B12)-0.53	*	(B9-2)*0.326	*	B4	Weight > 0	Water > 0
Mid soil back				(B11-4000)/1000	*	10*B6/B5								*	Log10(B13)-0.53	*	(B9-2)*0.326	*	B4	Weight > 0	Water > 0
Mid soil trailer	(	0.5	*	((B16-B20)/B19-4000)/1000*B19	*	10*B6/B5	+	0.5	*	((B17-B21)/B19-4000)/1000*B19	*	10*B6/B5	)	*	Log10(B18)-0.53	*	(B9-2)*0.326	*	B4	Weight > 0	Water > 0
Bottom soil front				(B10-6000)/1000	*	10*B6/B5								*	Log10(B12)-0.27	*	(B9-2)*0.272	*	B4	Weight > 0	Water > 0
Bottom soil back				(B11-6000)/1000	*	10*B6/B5								*	Log10(B13)-0.27	*	(B9-2)*0.272	*	B4	Weight > 0	Water > 0
Bottom soil trailer	(	0.5	*	((B16-B20)/B19-6000)/1000*B19	*	10*B6/B5	+	0.5	*	((B17-B21)/B19-6000)/1000*B19	*	10*B6/B5	)	*	Log10(B18)-0.27	*	(B9-2)*0.272	*	B4	Weight > 0	Water > 0

Plows

		Factor		Weight		Distance		Factor		Weight		Distance			Tire pressure		Water		Passes	Condition 1	Condition 2
Top soil front				B10/1000	*	10*B6/B5								*	Log10(B12)-1.2	*	B8*0.2625-0.056	*	B4		
Top soil back				(B11+B20)/1000	*	10*B6/B5								*	Log10(B13)-1.2	*	B8*0.2625-0.056	*	B4		
Mid soil front	(	0.5	*	(B10-4000)/1000	*	10*B6/B5	+	0.5	*	B10/1000	*	10*B6/B5	)	*	Log10(B12)-0.53	*	(B9-2)*0.326	*	B4	Weight > 0	Water > 0
Mid soil back	(	0.5	*	(B11-4000)/1000	*	10*B6/B5	+	0.5	*	B11/1000	*	10*B6/B5	)	*	Log10(B13)-0.53	*	(B9-2)*0.326	*	B4	Weight > 0	Water > 0
Bottom soil front	(	0.5	*	(B10-6000)/1000	*	10*B6/B5	+	0.5	*	(B10-3000)/1000	*	10*B6/B5	)	*	Log10(B12)-0.27	*	(B9-2)*0.272	*	B4	Weight > 0	Water > 0
Bottom soil back	(	0.5	*	(B11-6000)/1000	*	10*B6/B5	+	0.5	*	(B11-3000)/1000	*	10*B6/B5	)	*	Log10(B13)-0.27	*	(B9-2)*0.272	*	B4	Weight > 0	Water > 0

Cell code

B4	Number of operations
B5	Working width
B6	Extra driving
B7	Clay content
B8	Soil moisture class, topsoil
B9	Soil moisture class, subsoil
B10	Weight tractor front
B11	Weight tractor back
B12	Inflation pressure, front
B13	Inflation pressure, back
B14	not needed
B15	not needed
B16	Weight trailer full
B17	Weight trailer empty
B18	Inflation pressure, trailer
B19	Number of trailer axes
B20	Weight transmission to tractor

11.9 CHARACTERIZATION FACTORS

Crop	Soil layer			Unit: corrected ton-kilometers
	top soil	mid soil	bottom soil	
Corncob mix, OeLN intensive, from field	104.8	61.9	24.6	
Corncob mix, OeLN, from field	133.1	70.8	28.6	
Corncob mix, organic, from field	164.9	77.8	34.3	
Emmer, organic, wholesale	216.6	103.6	43.7	
Fava beans, OeLN intensive, wholesale	99.6	57.5	24.6	
Fava beans, OeLN, wholesale	88.9	53.8	24.6	
Fava beans, organic, wholesale	125.3	62.4	30.3	
Fodder beet, OeLN intensive, wholesale	204.8	97.2	24.4	
Fodder beet, OeLN, wholesale	227.1	104.0	28.4	
Fodder beet, organic, wholesale	235.4	105.8	34.1	
Grain maize, OeLN intensive, wholesale	109.3	62.8	24.6	
Grain maize, OeLN, wholesale	137.7	71.7	28.6	
Grain maize, organic, wholesale	169.4	78.7	34.3	
Machine beans, OeLN	180.7	63.8	3.6	
Machine beans, organic	194.1	55.4	3.9	
Meadow forage, OeLN intensive, sale	486.3	206.1	39.8	
Meadow forage, OeLN, sale	503.3	216.1	44.3	
Meadow forage, organic, sale	519.0	228.7	50.3	
Meadow, OeLN	431.4	197.0	46.3	
Meadow, OeLN intensive	431.1	197.4	45.8	
Meadow, organic	438.8	204.3	50.3	
Oat, OeLN extensive, retail	192.6	89.7	34.0	
Oat, organic, retail	222.0	103.6	43.7	
Potatoes, OeLN intensive, retail	528.1	255.5	65.6	
Potatoes, OeLN intensive, wholesale	528.1	255.5	65.6	
Potatoes, OeLN, retail	583.0	282.2	69.6	
Potatoes, OeLN, wholesale	583.0	282.2	69.6	
Potatoes, organic, retail	619.4	283.5	75.3	
Potatoes, organic, wholesale	619.4	283.5	75.3	
Processing potatoes, OeLN intensive, wholesa	528.1	255.5	65.6	
Processing potatoes, OeLN, wholesale	583.0	282.2	69.6	
Processing potatoes, organic, wholesale	619.4	283.5	75.3	
Protein peas, OeLN intensive, wholesale	122.0	69.2	24.6	
Protein peas, OeLN, wholesale	88.9	53.8	24.6	
Protein peas, organic, wholesale	117.1	62.4	30.3	
Rapeseed, OeLN intensive, wholesale	153.7	74.4	24.6	
Rapeseed, OeLN, wholesale	132.6	67.9	28.6	
Rapeseed, organic, wholesale	158.3	72.9	34.3	
Rye, OeLN extensive, retail	192.6	89.7	34.0	
Rye, OeLN extensive, wholesale	192.6	89.7	34.0	
Rye, OeLN intensive, wholesale	186.7	82.9	30.0	
Rye, organic, retail	222.0	103.6	43.7	
Rye, organic, wholesale	222.0	103.6	43.7	
Silage maize, OeLN intensive, standing from fi	137.2	87.1	38.8	
Silage maize, OeLN, standing from field	165.5	95.9	42.8	
Silage maize, organic, standing from field	197.3	103.0	48.5	
Soy, OeLN intensive, wholesale	110.8	63.3	24.6	
Soy, OeLN, wholesale	100.1	59.7	24.6	
Soy, organic, wholesale	136.5	68.3	30.3	
Spelt, OeLN extensive, retail	192.6	89.7	34.0	
Spelt, OeLN extensive, wholesale	192.6	89.7	34.0	
Spelt, OeLN intensive, wholesale	186.7	82.9	30.0	
Spelt, organic, retail	216.6	103.6	43.7	
Spelt, organic, wholesale	216.6	103.6	43.7	
Sugar beet, OeLN intensive, wholesale	156.2	65.4	11.0	
Sugar beet, OeLN, wholesale	172.4	70.1	15.0	
Sugar beet, organic, wholesale	185.2	73.5	20.7	
Summer oat, OeLN extensive, wholesale	188.0	88.2	34.0	
Summer oat, OeLN intensive, wholesale	182.1	81.4	30.0	
Summer oat, organic, wholesale	216.6	103.6	43.7	
Summer wheat TOP, OeLN extensive, wholesa	192.6	89.7	34.0	
Summer wheat TOP, OeLN intensive, wholesa	186.7	82.9	30.0	
Summer wheat TOP, organic, wholesale	221.2	105.1	43.7	
Sunflower, OeLN intensive, wholesale	120.5	68.7	24.6	
Sunflower, OeLN, wholesale	110.1	65.8	28.6	
Sunflower, organic, wholesale	141.9	72.9	34.3	
Threshing peas, OeLN	181.1	61.5	3.6	
Threshing peas, organic	196.0	58.4	3.9	
Tobacco, Burley, OeLN, air dried	327.7	112.7	13.0	
Tobacco, Virgine, OeLN, air dried	327.7	112.7	13.0	
Triticale, OeLN extensive, wholesale	188.0	88.2	34.0	
Triticale, OeLN intensive, wholesale	182.1	81.4	30.0	
Triticale, organic, wholesale	216.6	103.6	43.7	
Winter barley, OeLN extensive, wholesale	188.0	88.2	34.0	
Winter barley, OeLN intensive, wholesale	182.1	81.4	30.0	
Winter barley, organic, wholesale	216.6	103.6	43.7	
Winter wheat TOP, OeLN extensive, retail	192.6	89.7	34.0	
Winter wheat TOP, OeLN extensive, wholesale	192.6	89.7	34.0	
Winter wheat TOP, OeLN intensive, wholesale	186.7	82.9	30.0	
Winter wheat TOP, organic, retail	222.0	103.6	43.7	
Winter wheat TOP, organic, wholesale	222.0	103.6	43.7	

id_name	country	cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
		top soil	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Afghanistan	Afghanistan	0.00015212	2.94721E-05	0.000245867	0.00018168	3.81548E-05	0.000318309
Albania	Albania	0.000463629	0.000181132	0.001511115	0.000463345	0.000181255	0.001512132
Algeria	Algeria	5.56569E-05	4.47306E-06	3.73515E-05	0.000307796	7.12147E-05	0.000594278
American Samoa	American Samoa	0.00056441	0.0002445	0.00204			
Swains Island	American Samoa						
Andorra	Andorra	0.000242049	0.000238198	0.001987114	0.000241081	0.000238533	0.001989857
Angola	Angola	0.000219436	8.535E-05	0.000712082	0.000226119	8.85306E-05	0.000738594
Cabinda	Angola	0.000325849	0.000119562	0.000997618	0.000269174	0.000109376	0.000912762
Anguilla	Anguilla	0.000475617	0.000136233	0.001135454			
Antarctica	Antarctica						
Antigua and Barbuda	Antigua and Barbuda	0.000538757	0.000147784	0.001233688			
Buenos Aires	Argentina	0.000318261	0.000104187	0.000869208	0.000318174	0.000103755	0.000865599
Catamarca	Argentina	0.000110584	2.28979E-06	1.92592E-05	0.000130381	4.32477E-06	3.6364E-05
Chaco	Argentina	0.000264423	7.63944E-05	0.000637427	0.000279534	8.32602E-05	0.000694719
Chubut	Argentina	0.000128116	1.81995E-05	0.000152024	0.000198527	8.09796E-05	0.000675711
Ciudad de Buenos Aires	Argentina	0.000394579	0.00017051	0.001423049			
Córdoba	Argentina	0.000240362	5.99358E-05	0.000500159	0.000240427	6.0274E-05	0.00050299
Corrientes	Argentina	0.000396042	0.000162795	0.001358346	0.000395689	0.000161632	0.001348637
Entre Ríos	Argentina	0.000369435	0.000135851	0.001133188	0.000367171	0.000136893	0.001141848
Formosa	Argentina	0.000260886	7.55494E-05	0.000630163	0.00028447	8.9681E-05	0.000747987
Jujuy	Argentina	0.00014093	1.43078E-05	0.000119435	0.00020127	3.39195E-05	0.000283054
La Pampa	Argentina	0.000150387	1.5974E-05	0.00013365	0.000172107	2.50653E-05	0.000209577
La Rioja	Argentina	0.000118809	1.71852E-06	1.45245E-05	0.000125121	2.26742E-06	1.90973E-05
Mendoza	Argentina	0.000148809	1.72134E-05	0.000143698	0.000177039	3.59789E-05	0.000300337
Misiones	Argentina	0.000757464	0.000208864	0.001741999	0.000753144	0.000208168	0.001736231
Neuquén	Argentina	0.000163772	4.97081E-05	0.000414803	0.000179652	5.46212E-05	0.000455764
Río Negro	Argentina	0.000114559	1.05813E-05	8.84686E-05	0.000139645	2.42877E-05	0.000202917
Salta	Argentina	0.000182521	2.95543E-05	0.000246767	0.000199927	3.40306E-05	0.000284158
San Juan	Argentina	0.000105791	4.78253E-06	3.99669E-05	0.000106928	6.63275E-06	5.54371E-05
San Luis	Argentina	0.000176679	1.58142E-05	0.000132612	0.000181861	1.78908E-05	0.000149947
Santa Cruz	Argentina	0.000141339	2.25473E-05	0.000188681	0.000148116	1.94432E-05	0.000162445
Santa Fe	Argentina	0.000316396	0.000101447	0.00084652	0.000315161	0.00010094	0.000842286
Santiago del Estero	Argentina	0.00018389	3.00575E-05	0.000251014	0.00018567	3.08682E-05	0.000257749
Tierra del Fuego	Argentina	0.000294991	0.000152915	0.00127591	0.000297544	0.000141439	0.001180117
Tucumán	Argentina	0.000247988	5.29219E-05	0.000441753	0.000248559	5.31488E-05	0.000443647
Armenia	Armenia	0.000283569	8.83797E-05	0.000737459	0.000283685	8.86344E-05	0.000739584
Aruba	Aruba	0.000248256	1.71716E-05	0.000143249			

id_name	country	cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
		top soil	mid soil	bottom soil	top soil	mid soil	bottom soil
Ashmore and Cartier Islands	Australia						
Australian Capital Territory	Australia	0.000255519	0.000134405	0.001121307	0.000205708	8.70431E-05	0.000726092
Coral Sea Islands	Australia	0.000452443	0.000159986	0.001335714			
Lord Howe Island	Australia	0.00058205	0.000238925	0.0019925			
Macquarie Island	Australia	0.000258411	0.0002445	0.00204			
New South Wales	Australia	0.000242557	4.83495E-05	0.000403455	0.000263493	5.01879E-05	0.000418726
Northern Territory	Australia	0.000156346	2.32396E-05	0.000194012			
Queensland	Australia	0.000226747	3.26648E-05	0.000272793	0.000258686	5.72878E-05	0.000478207
South Australia	Australia	0.000117062	5.22772E-06	4.36759E-05	0.000192434	3.11716E-05	0.000260331
Tasmania	Australia	0.000394868	0.000193148	0.001611502	0.000370171	0.000154793	0.001291187
Victoria	Australia	0.000282873	9.0144E-05	0.000752295	0.000274611	7.09741E-05	0.000592383
Western Australia	Australia	0.000121786	9.97131E-06	8.33127E-05	0.000154605	3.13293E-05	0.00026146
Austria	Austria	0.000315099	0.000215855	0.001800844	0.000326594	0.000199931	0.001668014
Azerbaijan (main)	Azerbaijan	0.000295963	6.68107E-05	0.00055747	0.00029641	6.66463E-05	0.000556105
Nagorno Karabakh	Azerbaijan	0.000322837	8.19485E-05	0.000683804	0.000322837	8.19485E-05	0.000683804
Nakhichevan	Azerbaijan	0.000221311	2.9163E-05	0.000243514	0.000221901	2.98676E-05	0.000249411
Bahamas	Bahamas	0.000411634	0.000139167	0.00116146			
Bahrain	Bahrain	7.56019E-05	0	0	0.000106325	0	0
Bangladesh	Bangladesh	0.000450804	0.000163175	0.001361374	0.000450079	0.00016321	0.001361627
Barbados	Barbados	0.000627781	0.000159086	0.001327936			
Belarus	Belarus	0.000163596	0.000177975	0.001484809	0.000164329	0.000177752	0.001482943
Belgium	Belgium	0.000258387	0.000198721	0.00165763	0.000257625	0.000198601	0.001656632
Belize	Belize	0.000645804	0.000202767	0.001691431	0.000645384	0.000200151	0.001669606
Benin	Benin	0.000219014	8.36755E-05	0.000698292	0.000218727	8.37097E-05	0.000698565
Bermuda	Bermuda	0.000474793	0.000234029	0.001954643			
Bhutan	Bhutan	0.000288309	0.000149536	0.001247541	0.000288448	0.00014942	0.001246576
Bolivia	Bolivia	0.000307564	9.88341E-05	0.000824646	0.000302819	9.57933E-05	0.000799261
Bonaire	Bonaire	0.000294312	2.85167E-05	0.00023965			
Bosnia and Herzegovina	Bosnia and Herzegovina	0.00043961	0.000197287	0.001645937	0.00043991	0.000196662	0.001640755
Botswana	Botswana	7.04177E-05	4.99392E-06	4.16472E-05	7.58484E-05	5.38098E-06	4.48088E-05
Acre	Brazil	0.000455047	0.000179101	0.001493698	0.000454082	0.000178224	0.001486192
Alagoas	Brazil	0.00030374	0.000101969	0.000850879	0.000302966	0.00010148	0.000846809
Amapá	Brazil	0.000585858	0.000197257	0.001645916	0.000578522	0.000196282	0.001637963
Amazonas	Brazil	0.000498391	0.00021516	0.001795021	0.000525721	0.000208111	0.001736106
Bahia	Brazil	0.000284071	6.83002E-05	0.000569868	0.000284339	6.82536E-05	0.000569475
Brazilia Distrito Federal	Brazil	0.000551567	0.000151498	0.001264146	0.000551654	0.000151503	0.001264189
Ceará	Brazil	0.000218486	7.13773E-05	0.00059566	0.000218086	7.11361E-05	0.000593644

		cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
id_name	**country**	**top soil**	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Espírito Santo	Brazil	0.000454805	0.000127264	0.001061899	0.000455621	0.000127129	0.00106076
Fernando de Noronha	Brazil	0.000501642	0.0001483	0.00124			
Goiás	Brazil	0.000435564	0.000141035	0.001176747	0.000437444	0.000141185	0.001177995
Maranhão	Brazil	0.000341467	0.000121637	0.001014889	0.000324368	0.000118743	0.000990733
Mato Grosso	Brazil	0.000357384	0.000143806	0.001199866	0.000349088	0.000141449	0.001180132
Mato Grosso do Sul	Brazil	0.00035362	0.000144724	0.001207355	0.000358919	0.000145563	0.001214373
Minas Gerais	Brazil	0.000457855	0.00011922	0.00099478	0.000466583	0.000121826	0.001016501
Pará	Brazil	0.000520973	0.000170519	0.00142269	0.000501249	0.000166329	0.001387789
Paraíba	Brazil	0.000224248	6.48172E-05	0.000540972	0.000227086	6.7009E-05	0.000559243
Paraná	Brazil	0.000769264	0.000198484	0.001655939	0.000763853	0.000197052	0.001644
Pernambuco	Brazil	0.000223736	5.56102E-05	0.000463972	0.000224545	5.60155E-05	0.000467337
Piauí	Brazil	0.00021691	7.16034E-05	0.000597478	0.000221534	7.50237E-05	0.000626019
Rio de Janeiro	Brazil	0.000491653	0.000156561	0.001306082	0.000497128	0.000156906	0.00130895
Rio Grande do Norte	Brazil	0.000191047	5.52535E-05	0.000461199	0.000190993	5.52964E-05	0.000461574
Rio Grande do Sul	Brazil	0.000644118	0.000207629	0.001731897	0.000645944	0.000207565	0.001731368
Rondônia	Brazil	0.000417449	0.000159951	0.001334593	0.000421361	0.000161301	0.001346028
Roraima	Brazil	0.00047001	0.000167205	0.001395044	0.000388938	0.00014953	0.001247738
Santa Catarina	Brazil	0.000805618	0.000227548	0.001898553	0.000806997	0.000227512	0.001898241
São Paulo	Brazil	0.000475664	0.00014855	0.001239228	0.000470465	0.000145264	0.00121182
Sergipe	Brazil	0.000303475	9.81086E-05	0.00081871	0.000302098	9.71453E-05	0.00081069
Tocantins	Brazil	0.000333557	0.000136099	0.001135624	0.000333872	0.000135849	0.001133555
Trindade	Brazil						
Chagos Archipelago	British Indian Ocean Territory	0.000817955	0.0002445	0.00204			
British Virgin Islands	British Virgin Islands	0.000560194	0.0001656	0.001381417			
Brunei	Brunei	0.000536609	0.000244459	0.002039688	0.000538524	0.000244467	0.002039746
Bulgaria	Bulgaria	0.00035008	0.000112435	0.000938201	0.000353697	0.000109761	0.000915914
Burkina Faso	Burkina Faso	0.000183238	4.81496E-05	0.000401698	0.000181946	4.70746E-05	0.000392721
Burundi	Burundi	0.000478819	0.000129398	0.001079432	0.000482103	0.00012997	0.001084192
Cambodia	Cambodia	0.000427982	0.00014602	0.001218377	0.00042788	0.000146105	0.001219067
Cameroon	Cameroon	0.000497704	0.000145348	0.001212803	0.0004111	0.000123673	0.001031988
Alberta	Canada	0.000311689	0.000123284	0.001028773	0.00029987	9.5602E-05	0.000797778
British Columbia	Canada	0.000211614	0.000173905	0.001450841	0.000236367	0.000153874	0.001283778
Labrador	Canada	0.000167795	0.00023418	0.001954192	0.000169692	0.000234144	0.001954545
Manitoba	Canada	0.000402896	0.000168878	0.001408677	0.000355937	0.000120261	0.001003304
New Brunswick	Canada	0.000254189	0.000211965	0.001767754	0.000258868	0.000211707	0.001765595
Newfoundland	Canada	0.000216982	0.000233057	0.001944252	0.000221071	0.000234807	0.001958968
Northwest Territories	Canada	0.00026437	0.000177009	0.001476735			

id_name	country	cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
		top soil	mid soil	bottom soil	top soil	mid soil	bottom soil
Nova Scotia	Canada	0.000238623	0.00022345	0.001863396	0.000246676	0.000221882	0.001850234
Nunavut	Canada	0.000311189	0.000195338	0.001629834			
Ontario	Canada	0.000318998	0.000200604	0.00167371	0.000300282	0.000196958	0.001643529
Prince Edward Island	Canada	0.000237042	0.000214194	0.001786632			
Québec	Canada	0.000218786	0.000225259	0.001879311	0.000245179	0.000216213	0.001803559
Saskatchewan	Canada	0.000306787	0.000117772	0.000982615	0.000295871	7.8224E-05	0.000652675
Yukon	Canada	0.000242384	0.000142882	0.00119179			
Cape Verde	Cape Verde	0.000232483	1.88639E-05	0.000157428			
Cayman Islands	Cayman Islands	0.000626374	0.000168934	0.001408429			
Central African Republic	Central African Republic	0.000397574	0.000115115	0.00096045	0.000382848	0.0001112	0.000927757
Chad	Chad	0.000103387	1.6306E-05	0.000136079	0.00019072	3.51762E-05	0.000293564
Aisén del General Carlos Ibáñez del Campo	Chile	0.000270243	0.000221419	0.001847377	0.000272571	0.000216145	0.001803338
Antofagasta	Chile	5.43727E-05	1.60155E-10	1.33994E-09	6.30214E-05	0	0
Araucanía	Chile	0.000360883	0.000164416	0.001371661	0.000362417	0.000164235	0.001370143
Atacama	Chile	7.13654E-05	9.61648E-08	8.09737E-07	6.94461E-05	3.92228E-08	3.28716E-07
Bío-Bío	Chile	0.000327027	0.000144958	0.001209646	0.000324766	0.000143837	0.001200303
Coquimbo	Chile	0.000124097	4.31348E-06	3.58023E-05	0.000124286	4.59398E-06	3.81181E-05
Desventurados Islands	Chile	0.0001826	0	0			
Easter Islands	Chile	0.000511946	0.000187757	0.001566582			
Juan Fernandez Islands	Chile	0.000404637	0.00014894	0.001243			
Libertador General Bernardo O'Higgins	Chile	0.000258252	0.000101544	0.000847381	0.000258646	0.000101596	0.000847823
Los Lagos	Chile	0.000350097	0.000215241	0.001795625	0.000359617	0.000210142	0.001753055
Magallanes y Antártica Chilena	Chile	0.00025358	0.00019068	0.00159084	0.000253493	0.000179197	0.001495049
Maule	Chile	0.000279897	0.000118802	0.000991301	0.000279868	0.000118766	0.000990982
Región Metropolitana de Santiago	Chile	0.000229508	7.09141E-05	0.000591795	0.000230598	7.18764E-05	0.000599818
Tarapacá	Chile	6.53715E-05	2.0703E-06	1.73871E-05	9.75257E-05	4.49749E-06	3.7868E-05
Valparaíso	Chile	0.000188923	4.02378E-05	0.000335679	0.00018914	4.21711E-05	0.000351846
Anhui	China	0.000413016	0.000176335	0.001470799	0.00041129	0.000174105	0.001452192
Beijing	China	0.00019074	8.00062E-05	0.000667457	0.000189963	7.99042E-05	0.000666587
Chongqing	China	0.000471031	0.000217978	0.001818161	0.000471132	0.000217954	0.001817965
Fujian	China	0.000465933	0.000216284	0.001804202	0.000466168	0.000216311	0.001804425
Gansu	China	0.000146892	4.77718E-05	0.000398709	0.000181425	7.03378E-05	0.000587042
Guangdong	China	0.000447544	0.000198564	0.001656386	0.000447405	0.000198577	0.00165649
Guangxi	China	0.00048061	0.000191137	0.001594505	0.000480841	0.000191576	0.001598177
Guizhou	China	0.000510279	0.000200028	0.001668813	0.00051033	0.000200038	0.001668896

		cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
id_name	**country**	**top soil**	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Hainan	China	0.000433026	0.000166274	0.001386899	0.000434729	0.000166747	0.001390836
Hebei	China	0.000187322	7.32887E-05	0.000611497	0.000187252	7.32753E-05	0.000611387
Heilongjiang	China	0.000359809	0.000140154	0.001169602	0.000358027	0.000135997	0.001134945
Henan	China	0.0002857	0.000105353	0.000879037	0.000285594	0.000105312	0.000878698
Hubei	China	0.000419865	0.000193073	0.001610633	0.000419572	0.000192884	0.001609049
Hunan	China	0.000461368	0.0002171	0.00181102	0.000461926	0.000216927	0.001809566
Jiangsu	China	0.000387969	0.000164509	0.001372775	0.000386756	0.000163977	0.001368318
Jiangxi	China	0.000441278	0.000202954	0.001693238	0.00044125	0.000201991	0.001685217
Jilin	China	0.000295194	0.000137848	0.001150073	0.000295162	0.000131875	0.001100224
Liaoning	China	0.000268874	0.000136877	0.00114221	0.000268262	0.000136693	0.001140677
Nei Mongol	China	0.000175763	4.72517E-05	0.000394413	0.000192237	5.535E-05	0.000462021
Ningxia Hui	China	0.00014293	2.76144E-05	0.000230916	0.000144168	2.83806E-05	0.000237315
Paracel Islands	China						
Qinghai	China	0.000168348	7.74118E-05	0.000645988	0.000191195	9.80271E-05	0.000818013
Shaanxi	China	0.000238129	0.000106915	0.000891966	0.000235585	0.000104498	0.000871802
Shandong	China	0.000252593	0.000104236	0.000869703	0.000252248	0.000104093	0.000868511
Shanghai	China	0.000422082	0.000202313	0.001688406	0.000420973	0.000201332	0.00168024
Shanxi	China	0.000181151	7.21782E-05	0.000602383	0.000181044	7.21944E-05	0.000602518
Sichuan	China	0.00031601	0.000169607	0.001415003	0.000316455	0.000169636	0.001415252
Tianjin	China	0.000233892	7.76539E-05	0.000647676	0.000232229	7.77455E-05	0.000648461
Xinjiang Uygur	China	0.000114389	1.11713E-05	9.33644E-05	0.000146302	2.48397E-05	0.00020743
Xizang	China	0.000146842	5.81154E-05	0.000485079	0.000146612	7.0837E-05	0.000591156
Yunnan	China	0.000437536	0.000153309	0.001278851	0.000437145	0.000153187	0.001277834
Zhejiang	China	0.000453438	0.000231684	0.001932587	0.000453356	0.000231378	0.001930024
Christmas Island	Christmas Island	0.000770877	0.000215981	0.001803023			
Clipperton Island	Clipperton Island						
Cocos (Keeling) Islands	Cocos (Keeling) Islands	0.00072368	0.00022656	0.00189			
Colombia	Colombia	0.00046606	0.000208289	0.001737679	0.000497944	0.000200105	0.001669386
Colombian Caribbean Islands	Colombia						
Malpelo Island	Colombia						
Comoros	Comoros	0.000711597	0.000211513	0.001764342			
Cook Islands	Cook Islands	0.000652697	0.000239164	0.001995909			
Manihiki Island	Cook Islands	0.0009094	0.0002445	0.00204			
Cocos Island	Costa Rica						
Costa Rica	Costa Rica	0.000559258	0.000203279	0.001696038	0.000558315	0.000198775	0.001658437
Cote d'Ivoire	Cote d'Ivoire	0.000309574	0.000122116	0.001018684	0.0003066	0.000120402	0.001004374
Croatia	Croatia	0.000457233	0.000186883	0.001559085	0.000449109	0.000184569	0.001539803

id_name	country	cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
		top soil	mid soil	bottom soil	top soil	mid soil	bottom soil
Cuba	Cuba	0.000594797	0.000147044	0.001226868	0.000606999	0.000147726	0.00123261
Curacao	Curacao	0.000340674	4.26854E-05	0.000357205			
Cyprus	Cyprus	0.000261852	5.7708E-05	0.00048172	0.000263134	5.38014E-05	0.000449109
Czech Republic	Czech Republic	0.000282379	0.000169398	0.00141346	0.00028365	0.000166929	0.001392885
Democratic Republic of the Congo	Democratic Republic of the Congo	0.000467431	0.000168375	0.001404604	0.000368917	0.000140139	0.001169083
Denmark	Denmark	0.000217313	0.000208196	0.001736546	0.000211304	0.000208397	0.001738215
Djibouti	Djibouti	9.48046E-05	2.19065E-09	2.34146E-08	0.000116817	0	0
Dominica	Dominica	0.000729418	0.000235696	0.001966435			
Dominican Republic	Dominican Republic	0.000519843	0.000147423	0.001229944	0.000521196	0.000147899	0.001233912
East Timor	East Timor	0.000430856	0.000153001	0.00127652	0.000433492	0.000154399	0.001288183
Ecuador	Ecuador	0.000456905	0.000179592	0.001498308	0.000449282	0.00017261	0.001440107
Galápagos	Ecuador	0.000383004	7.05411E-05	0.000588696			
Egypt	Egypt	3.93533E-05	2.00991E-06	1.67626E-05	0.000215278	3.62839E-05	0.000302492
Sinai	Egypt	6.05289E-05	2.61577E-07	2.18436E-06	0.000195967	5.10627E-05	0.000425317
El Salvador	El Salvador	0.000500483	0.000134838	0.001124742	0.000500451	0.000134922	0.001125451
Annobón	Equatorial Guinea						
Bioko	Equatorial Guinea	0.000621953	0.000210261	0.001754212	0.000617147	0.000212017	0.001768809
Equatorial Guinea	Equatorial Guinea	0.000699561	0.000213041	0.001777202	0.000646627	0.000212734	0.001774982
Eritrea	Eritrea	0.000144196	8.74329E-06	7.29503E-05	0.000205648	1.94872E-05	0.00016253
Estonia	Estonia	0.000253935	0.000200345	0.001671381	0.000254379	0.000200519	0.00167285
Ethiopia	Ethiopia	0.000333038	5.23184E-05	0.00043669	0.000383667	6.37183E-05	0.000531754
Falkland Islands	Falkland Islands	0.000309059	0.000187611	0.00156512			
Faroe Islands	Faroe Islands	0.000214276	0.000244252	0.002037477			
Fiji	Fiji	0.0007241	0.00024176	0.00201702			
Finland	Finland	0.000152576	0.000204508	0.001706383	0.000231366	0.000199046	0.001661174
Channel Islands	France	0.000292646	0.000189697	0.001581938			
Corse	France	0.000343803	0.000166272	0.001386913	0.000335316	0.000171831	0.001433315
France	France	0.000355627	0.000174365	0.001454587	0.000358508	0.000172966	0.001442911
French Guiana	French Guiana	0.000622047	0.000212507	0.001772768	0.000621721	0.000211505	0.001764516
Marquesas	French Polynesia	0.00063017	0.000180623	0.001506942			
Society Island	French Polynesia	0.000681211	0.00023174	0.001933162			
Tuamotu	French Polynesia	0.000691008	0.000230952	0.001929			
Tubuai Island	French Polynesia	0.00073404	0.00024386	0.00203494			
Amsterdam-St.Paul Island	French Southern Territories						
Crozet Island	French Southern Territories	0.000301489	0.0002445	0.00204			
Kerguelen	French Southern Territories	0.000256375	0.000225546	0.001881839			

id_name	country	cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
		top soil	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Gabon	Gabon	0.000590605	0.000186057	0.00155245	0.00050731	0.000186677	0.001557898
Gambia	Gambia	0.000199646	5.83867E-05	0.000487145	0.000196197	5.78678E-05	0.00048278
Abkhaziya	Georgia	0.000407342	0.000230458	0.001923089	0.000398166	0.000231879	0.001935085
Adzhariya	Georgia	0.000383892	0.000207489	0.001731226	0.000349889	0.000211946	0.001768425
Gruziya	Georgia	0.000357604	0.000176992	0.001476407	0.000359844	0.000174955	0.001459399
Germany	Germany	0.000262746	0.000183019	0.001526686	0.000260846	0.000181803	0.001516546
Ghana	Ghana	0.000259787	0.000120612	0.001006291	0.000258087	0.00012055	0.001005773
Gibraltar	Gibraltar	0.000341883	0.00011855	0.000988333			
East Aegean Islands	Greece	0.000328636	0.000110306	0.000921002	0.000328538	0.000111317	0.000929409
Greece	Greece	0.00032895	0.000107623	0.000898002	0.000327438	0.000106666	0.000890036
Kriti	Greece	0.000356502	0.000124669	0.00104042	0.000359477	0.000126303	0.001053962
Greenland	Greenland	0.000273439	0.00022045	0.001839218			
Grenada	Grenada	0.000697452	0.000213968	0.001785315			
Guadeloupe	Guadeloupe	0.000687681	0.000208876	0.001742572			
Guam	Guam	0.000787344	0.000228264	0.001904837			
Guatemala	Guatemala	0.000579756	0.000175226	0.001461935	0.000578623	0.000175262	0.00146226
Guinea	Guinea	0.000390822	0.00011714	0.000977417	0.000398678	0.000118752	0.000990915
Guinea-Bissau	Guinea-Bissau	0.000327739	0.000102104	0.000851969	0.000328456	0.000101121	0.000843657
Guyana	Guyana	0.000513067	0.000190174	0.001586622	0.000498565	0.000190197	0.001586786
Haiti	Haiti	0.000533358	0.000164997	0.001376435	0.000537641	0.000167383	0.001396343
Heard Island and McDonald Islands	Heard Island and McDonald Islands	0.000241231	0.000233775	0.00194875			
Honduran Caribbean Islands	Honduras	0.000631815	0.000196281	0.001637721			
Honduras	Honduras	0.000558	0.000168901	0.001409032	0.000549912	0.000165075	0.001377138
Hong Kong	Hong Kong	0.000431648	0.000208293	0.001737695	0.00043267	0.000198617	0.001657826
Hungary	Hungary	0.000303024	0.000111215	0.000927975	0.000302894	0.000110646	0.00092322
Iceland	Iceland	0.000164372	0.000240015	0.00200255			
Andaman Island	India	0.00053901	0.000201765	0.001684196			
Andhra Pradesh	India	0.000368041	7.69713E-05	0.000642349	0.000368043	7.69785E-05	0.000642408
Arunachal Pradesh	India	0.000326565	0.00017374	0.001449735	0.000327654	0.000173848	0.001450648
Assam	India	0.000422555	0.00018217	0.001520062	0.000421378	0.000182304	0.001521155
Bihar	India	0.000378069	0.000110754	0.000923931	0.000378069	0.000110754	0.000923931
Chandigarh	India	0.00030842	9.99402E-05	0.000834444	0.00030842	9.99402E-05	0.000834444
Chhattisgarh	India	0.000414823	0.000100943	0.000841875	0.000414661	0.000100956	0.00084198
Dadra and Nagar Haveli	India	0.000484693	0.000103389	0.000862785	0.000484693	0.000103389	0.000862785
Daman and Diu	India	0.000504352	9.78047E-05	0.00081574	0.000506271	9.77961E-05	0.000815779
Delhi	India	0.000255343	5.15405E-05	0.000430141	0.000254762	5.13128E-05	0.00042825
Diu	India	0.000442808	8.89394E-05	0.000741364	0.000445676	8.89132E-05	0.000742368

id_name	country	cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
		top soil	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Goa	India	0.000481553	0.000130407	0.001086685	0.000482494	0.000130398	0.001086608
Gujarat	India	0.000347686	4.92676E-05	0.00041089	0.000360136	5.26936E-05	0.000439427
Haryana	India	0.000284535	7.01418E-05	0.000584617	0.000284535	7.01418E-05	0.000584617
Himachal Pradesh	India	0.000342572	0.000176563	0.001473081	0.000349204	0.000180459	0.001505561
Jammu and Kashmir	India	0.000199267	7.19256E-05	0.000600179	0.000220494	8.78187E-05	0.000732723
Jharkhand	India	0.000395165	0.000106152	0.000885741	0.000395165	0.000106152	0.000885741
Karaikal	India	0.000475738	0.000113276	0.000944017	0.000479667	0.000115045	0.000958863
Karnataka	India	0.000375697	6.59542E-05	0.000550315	0.000375377	6.57164E-05	0.00054833
Kerala	India	0.000502389	0.000175816	0.001466755	0.000502427	0.000175757	0.001466246
Lakshadweep	India	0.000613667	0.0001888	0.00158			
Madhya Pradesh	India	0.000466515	8.65605E-05	0.000722266	0.000466673	8.6546E-05	0.000722149
Maharashtra	India	0.000479315	7.55835E-05	0.000630785	0.000479629	7.52639E-05	0.000628122
Mahé	India	0.000541938	0.000161838	0.001347692	0.000541938	0.000161838	0.001347692
Manipur	India	0.000454486	0.000174046	0.001452953	0.000453977	0.000174536	0.001456996
Meghalaya	India	0.00047188	0.000188097	0.001569027	0.000476725	0.00018964	0.001581732
Mizoram	India	0.000465885	0.000179994	0.001501584	0.000466565	0.000180222	0.001503482
Nagaland	India	0.000444984	0.000179662	0.001499676	0.000445538	0.00018023	0.00150438
Nicobar Islands	India	0.000639473	0.000229295	0.001913243			
Orissa	India	0.000420605	0.000117539	0.00098088	0.000420444	0.000117512	0.000980656
Puducherry	India	0.000478007	0.000115715	0.000964935	0.000479633	0.000116041	0.000967615
Punjab	India	0.000295454	7.83739E-05	0.000653057	0.000296017	7.86565E-05	0.000655401
Rajasthan	India	0.000216481	2.68084E-05	0.000223728	0.000221905	2.78376E-05	0.000232317
Sikkim	India	0.000235977	0.000148053	0.001235285	0.00023887	0.000150158	0.001252845
Tamil Nadu	India	0.000394661	8.25001E-05	0.00068834	0.000394436	8.2408E-05	0.00068757
Tripura	India	0.000416363	0.000173355	0.001446048	0.000416734	0.00017343	0.001446638
Uttar Pradesh	India	0.000343803	0.000106935	0.000892183	0.000343844	0.000106973	0.000892501
Uttaranchal	India	0.000384548	0.000182888	0.001525641	0.000385422	0.000182791	0.00152483
West Bengal	India	0.000416561	0.000136056	0.001134823	0.000416655	0.00013575	0.001132254
Yanam	India	0.000521934	0.000113779	0.000948358	0.000521934	0.000113779	0.000948358
Bali	Indonesia	0.000674336	0.000190441	0.001588656	0.000686165	0.000193894	0.001617464
Irian Jaya	Indonesia	0.000580636	0.0002389	0.001993176	0.000580469	0.000238979	0.001993833
Jawa	Indonesia	0.000679513	0.000199994	0.001668453	0.00068226	0.000200761	0.001674856
Kalimantan	Indonesia	0.000645018	0.000240865	0.002009687	0.000646117	0.00024089	0.002009901
Lesser Sunda Island	Indonesia	0.000519632	0.000163387	0.001363159	0.000524284	0.000164807	0.001374996
Maluku	Indonesia	0.000686383	0.000232662	0.001941209	0.000686869	0.000233155	0.001945361
Sulawesi	Indonesia	0.000658979	0.000220629	0.001840624	0.00066175	0.000221368	0.001846782
Sumatera	Indonesia	0.000695862	0.000233176	0.001945409	0.00069918	0.000233077	0.001944579

id_name	country	cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
		top soil	mid soil	bottom soil	top soil	mid soil	bottom soil
Iran	Iran	0.000133088	1.00373E-05	8.37688E-05	0.000198992	2.19132E-05	0.000182828
Iraq	Iraq	0.000137983	1.13876E-05	9.50992E-05	0.000217353	2.62868E-05	0.000219548
Ireland	Ireland	0.000326857	0.000222651	0.00185739	0.000336111	0.000221234	0.001845533
Israel	Israel	0.000182383	2.23169E-05	0.000186386	0.000276977	4.77896E-05	0.000398886
Italy (Mainland)	Italy	0.000404302	0.000175257	0.001461976	0.000411283	0.000170838	0.001425109
Sardegna	Italy	0.000332081	0.000115275	0.000961809	0.000338977	0.000114954	0.000959155
Sicilia	Italy	0.000365381	9.09408E-05	0.000758911	0.000368015	8.95057E-05	0.000746962
Jamaica	Jamaica	0.000753135	0.000212069	0.001769123	0.000755994	0.000213065	0.00177741
Hokkaido	Japan	0.000299928	0.000235408	0.001963725	0.000301228	0.000235421	0.001963848
Honshu	Japan	0.000385677	0.00024079	0.002008883	0.000388727	0.000240545	0.002006853
Kazan-retto	Japan	0.00062224	0.00023011	0.0019185			
Kyushu	Japan	0.000462489	0.000244363	0.00203886	0.000464208	0.00024436	0.002038831
Marcus Island	Japan						
Nansei-shoto	Japan	0.000539832	0.000244449	0.002039619	0.000529793	0.0002445	0.00204
Ogasawara-shoto	Japan	0.000703308	0.000240442	0.002005			
Shikoku	Japan	0.000450008	0.000243725	0.00203371	0.000457801	0.000243743	0.002033879
Jordan	Jordan	0.000109362	2.28446E-06	1.91362E-05	0.000208643	1.46393E-05	0.000122346
Kazakhstan	Kazakhstan	0.000213682	2.91621E-05	0.000243463	0.000251639	5.08127E-05	0.000424148
Kenya	Kenya	0.000254356	3.0357E-05	0.000253407	0.000270118	3.35861E-05	0.000280338
Gilbert Islands	Kiribati	0.000684014	0.000223319	0.00186381			
Kiribati	Kiribati	0.000517808	0.000201408	0.00168			
Phoenix Islands	Kiribati	0.000446529	8.91571E-05	0.000744286			
Kosovo	Kosovo	0.00038429	0.000168843	0.001408362	0.000384581	0.000169063	0.001410193
Kuwait	Kuwait	6.42017E-05	0	0	7.76229E-05	0	0
Kyrgyzstan	Kyrgyzstan	0.000230537	8.33618E-05	0.000695566	0.000232392	8.35635E-05	0.00069724
Laos	Laos	0.000427231	0.000144297	0.001203932	0.000426186	0.000144133	0.001202578
Latvia	Latvia	0.00023315	0.000201054	0.001676976	0.000234628	0.000200975	0.001676292
Lebanon	Lebanon	0.000374049	0.000102942	0.000858937	0.000376464	0.000102403	0.000854439
Lesotho	Lesotho	0.00030443	9.46315E-05	0.000789528	0.000306766	9.46817E-05	0.000789948
Liberia	Liberia	0.000460864	0.000194752	0.001624715	0.000461043	0.000198411	0.001655193
Libya	Libya	3.10396E-05	4.04067E-07	3.3752E-06	0.000194173	2.32901E-05	0.000194412
Liechtenstein	Liechtenstein	0.000361841	0.000240217	0.002004295	0.000357026	0.000240508	0.002006689
Lithuania	Lithuania	0.00021276	0.000192506	0.001605915	0.000215172	0.000192643	0.00160707
Luxembourg	Luxembourg	0.00037404	0.000196005	0.001635363	0.00037404	0.000196005	0.001635363
Macao	Macao	0.000398937	0.0002041	0.0017			
Macedonia	Macedonia	0.000304595	0.000110858	0.000925038	0.000304127	0.000109807	0.000916286
Madagascar	Madagascar	0.000337735	0.000112256	0.00093671	0.000335674	0.000113601	0.000947966

		cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
id_name	**country**	**top soil**	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Malawi	Malawi	0.000302413	9.94932E-05	0.000830179	0.000298102	9.82772E-05	0.000820008
Peninsular Malaysia	Malaysia	0.000622921	0.000231689	0.001932726	0.000624315	0.000231813	0.001933754
Sabah	Malaysia	0.000671241	0.000241995	0.002019044	0.0006737	0.000242216	0.002020911
Sarawak	Malaysia	0.000610939	0.000244425	0.002039372	0.000611897	0.000244431	0.002039421
Maldives	Maldives	0.000895467	0.000241367	0.002013333			
Mali	Mali	8.65746E-05	1.53505E-05	0.000128132	0.00017321	3.78367E-05	0.000315767
Malta	Malta	0.000306704	8.3686E-05	0.000698155			
Marshall Islands	Marshall Islands	0.000765412	0.000234225	0.001955			
Martinique	Martinique	0.000703286	0.000224145	0.001869959			
Mauritania	Mauritania	3.777E-05	2.52423E-07	2.13846E-06	6.91131E-05	1.89142E-06	1.60028E-05
Mauritius	Mauritius	0.000769368	0.000217924	0.00181876			
Rodrigues	Mauritius	0.000557903	0.000183154	0.001528305			
Mayotte	Mayotte	0.000503049	0.000147122	0.001228035			
Aguascalientes	Mexico	0.000338359	2.75356E-05	0.000229578	0.000338613	2.72166E-05	0.000226926
Baja California	Mexico	0.000172037	5.11121E-06	4.26589E-05	0.000175505	4.97098E-06	4.1448E-05
Baja California Sur	Mexico	0.000197386	1.06397E-06	8.91405E-06	0.000206061	1.59312E-06	1.33429E-05
Campeche	Mexico	0.000515185	0.000117822	0.000983191	0.000515672	0.00011789	0.00098373
Chiapas	Mexico	0.00053844	0.0001583	0.001320696	0.000538056	0.000158141	0.001319376
Chihuahua	Mexico	0.000295166	2.26315E-05	0.000188839	0.000290771	1.94422E-05	0.000162207
Coahuila	Mexico	0.000228797	2.42609E-06	2.07064E-05	0.000232116	2.60017E-06	2.22162E-05
Colima	Mexico	0.000430974	8.01303E-05	0.000668422	0.000431494	8.02968E-05	0.000669829
Durango	Mexico	0.000366791	5.20581E-05	0.000434418	0.000361236	4.73529E-05	0.00039513
Guadalupe Island	Mexico	0.000189655	3.81181E-06	3.23247E-05			
Guanajuato	Mexico	0.00036635	4.2541E-05	0.000355083	0.000366383	4.25133E-05	0.00035485
Guerrero	Mexico	0.000450229	9.5555E-05	0.00079734	0.000450662	9.54453E-05	0.00079643
Hidalgo	Mexico	0.000402423	7.92015E-05	0.000660837	0.000402423	7.92015E-05	0.000660837
Jalisco	Mexico	0.000433756	7.49848E-05	0.000625748	0.000434061	7.50869E-05	0.000626599
México	Mexico	0.000419098	9.42698E-05	0.000786724	0.000421679	9.38472E-05	0.000783202
Mexico Distrito Federal	Mexico	0.000372269	8.64677E-05	0.000721502	0.000400435	9.80179E-05	0.000817639
Michoacán	Mexico	0.000426606	8.67857E-05	0.000724148	0.00042664	8.67254E-05	0.000723653
Morelos	Mexico	0.000401371	7.20002E-05	0.000600578	0.000401371	7.20002E-05	0.000600578
Nayarit	Mexico	0.000471628	9.67124E-05	0.000806989	0.000472049	9.68973E-05	0.000808534
Nuevo León	Mexico	0.000282474	2.08864E-05	0.000174684	0.000281895	2.05094E-05	0.000171541
Oaxaca	Mexico	0.000450059	0.000109864	0.000916627	0.00045336	0.000111276	0.000928417
Puebla	Mexico	0.000397205	7.90304E-05	0.000659447	0.00039703	7.88199E-05	0.000657687
Querétaro	Mexico	0.000366004	5.13827E-05	0.000428983	0.000366016	5.13852E-05	0.000429003
Quintana Roo	Mexico	0.000522593	0.000120659	0.001006779	0.000520767	0.000119904	0.001000537

		cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
id_name	**country**	**top soil**	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Revillagigedo Islands	Mexico						
Rocas Alijos	Mexico						
San Luis Potosí	Mexico	0.000303095	3.19378E-05	0.000266599	0.000303378	3.20535E-05	0.000267564
Sinaloa	Mexico	0.000393033	6.18594E-05	0.000516252	0.000394499	6.25015E-05	0.000521602
Sonora	Mexico	0.000255104	1.17939E-05	9.86549E-05	0.000268681	1.27518E-05	0.000106674
Tabasco	Mexico	0.000592016	0.000191412	0.001596842	0.000592906	0.000191654	0.001598866
Tamaulipas	Mexico	0.000338788	4.9174E-05	0.000410493	0.000338648	4.90568E-05	0.000409524
Tlaxcala	Mexico	0.000369285	6.44128E-05	0.000537496	0.000368435	6.40652E-05	0.000534587
Veracruz	Mexico	0.000530362	0.000158258	0.001320288	0.000530521	0.000158092	0.001318901
Yucatán	Mexico	0.000408486	8.4169E-05	0.000702189	0.000409493	8.46642E-05	0.000706315
Zacatecas	Mexico	0.000295724	1.52762E-05	0.000127415	0.000296738	1.53463E-05	0.000127993
Micronesia	Micronesia	0.000733447	0.0002445	0.00204			
Moldova	Moldova	0.000373805	0.000108823	0.000908004	0.000373805	0.000108823	0.000908004
Monaco	Monaco	0.000465274	0.000180668	0.001507368	0.000478455	0.000184873	0.001542727
Mongolia	Mongolia	0.000154142	2.67447E-05	0.000223307	0.000188167	4.20673E-05	0.000351112
Montenegro	Montenegro	0.00042527	0.000211756	0.001766796	0.000422996	0.000212188	0.001770409
Montserrat	Montserrat	0.000648921	0.000222423	0.001855664			
Morocco	Morocco	0.000182478	2.22554E-05	0.0001858	0.000264233	4.46867E-05	0.000372872
Mozambique	Mozambique	0.000254216	7.93353E-05	0.000661929	0.000255571	7.93964E-05	0.000662429
Coco Island	Myanmar						
Myanmar	Myanmar	0.000446091	0.000145404	0.001213238	0.000443956	0.000145214	0.001211652
Caprivi Strip	Namibia	0.000103253	2.6969E-05	0.00022527	0.000119708	2.6885E-05	0.000224838
Namibia	Namibia	5.53194E-05	4.67072E-06	3.89049E-05	7.34295E-05	7.02556E-06	5.84219E-05
Nauru	Nauru	0.000604041	0.0002364	0.00197			
Nepal	Nepal	0.000333819	0.000151435	0.001263285	0.000334493	0.000151513	0.001263945
Netherlands	Netherlands	0.000273662	0.000199796	0.001666504	0.000269456	0.000199452	0.001663609
New Caledonia	New Caledonia	0.000532871	0.000211862	0.001767251			
Antipodean Islands	New Zealand	0.000270692	0.000243861	0.002034643			
Chatham Islands	New Zealand	0.000361608	0.00021345	0.001780798			
Kermadec Islands	New Zealand	0.00052719	0.00023103	0.0019265			
New Zealand North	New Zealand	0.000483258	0.000219919	0.001834775	0.000486415	0.000207825	0.001733755
New Zealand South	New Zealand	0.000347816	0.000211259	0.001762573	0.000360225	0.000175051	0.001460456
Nicaragua	Nicaragua	0.000571342	0.000185641	0.001549001	0.000567889	0.000184005	0.001535368
Nicaraguan Caribbean Islands	Nicaragua	0.000724733	0.000216633	0.001806667			
Niger	Niger	3.35101E-05	2.05957E-06	1.71546E-05	6.35268E-05	8.27157E-06	6.8851E-05
Nigeria	Nigeria	0.000220015	9.09257E-05	0.000758616	0.000217081	8.96143E-05	0.00074767
Niue	Niue	0.000625353	0.000244484	0.002039826			

id_name	country	cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
		top soil	mid soil	bottom soil	top soil	mid soil	bottom soil
Norfolk Island	Norfolk Island						
North Korea	North Korea	0.000322154	0.000209998	0.001751737	0.000322975	0.0002094	0.001746765
Northern Mariana Islands	Northern Mariana Islands	0.00081009	0.000228104	0.00190377			
Norway	Norway	0.000152888	0.000231045	0.001927319	0.000218674	0.000227326	0.001896528
Oman	Oman	3.5263E-05	1.64759E-08	1.36888E-07	9.19167E-05	3.76749E-07	3.10776E-06
Pakistan	Pakistan	0.000144158	1.93699E-05	0.000161585	0.000174912	2.73938E-05	0.000228529
Palau	Palau	0.000870728	0.0002445	0.00204			
Gaza	Palestine	0.000170691	1.98383E-05	0.000165431	0.000162409	1.78463E-05	0.000148731
West Bank	Palestine	0.000252674	3.85828E-05	0.000322022	0.00026663	4.27711E-05	0.000357011
Panama	Panama	0.000530881	0.000195813	0.001633673	0.000528698	0.000192351	0.001604806
Bismarck Archipelago	Papua New Guinea	0.000706963	0.000244204	0.002037504	0.00070631	0.00024431	0.002038398
North Solomons	Papua New Guinea	0.000742056	0.000244499	0.002039991	0.000745544	0.000244499	0.002039995
Papua New Guinea	Papua New Guinea	0.000610323	0.000233172	0.001945335	0.0006092	0.000233208	0.001945639
Paraguay	Paraguay	0.000333167	0.000102401	0.000854482	0.000352386	0.000112433	0.000938129
Peru	Peru	0.000385006	0.000150919	0.00125903	0.000347403	0.000121445	0.001013168
Philippines	Philippines	0.000584897	0.000211124	0.001761403	0.000586313	0.000211234	0.001762331
Pitcairn Islands	Pitcairn Islands	0.000641226	0.000237753	0.001982791			
Poland	Poland	0.000162218	0.000158531	0.001322845	0.000160286	0.00015758	0.001314918
Azores	Portugal	0.000440177	0.00019953	0.001664268			
Madeira	Portugal	0.000438626	0.00013636	0.001137286			
Portugal	Portugal	0.000270774	0.000127335	0.001062252	0.000267505	0.000122358	0.001020712
Selvagens	Portugal	0.0002524	3.87E-05	0.00032			
Navassa Island	Puerto Rico	0.000678433	0.000205133	0.00171			
Puerto Rico	Puerto Rico	0.000736886	0.000196295	0.001637587	0.000749683	0.000199628	0.001665402
Qatar	Qatar	5.3503E-05	0	0			
Republic of Congo	Republic of Congo	0.000514893	0.000180144	0.001502789	0.000479645	0.00018215	0.001519795
Reunion	Reunion	0.000721343	0.000219946	0.001834847			
Romania	Romania	0.000342628	0.000126021	0.001051302	0.000346796	0.000118231	0.000986331
Adygey	Russia	0.000416895	0.000178757	0.001491517	0.000445959	0.000165564	0.001381715
Altay	Russia	0.000311461	0.000107419	0.000896257	0.000308989	0.000100113	0.000835291
Amur	Russia	0.000377925	0.000185363	0.001546325	0.000405799	0.000166948	0.00139271
Arkhangel'sk (Islands)	Russia	0.000308586	0.000219535	0.001830738			
Arkhangel'sk (Mainland)	Russia	0.000221323	0.000203122	0.00169499	0.000263398	0.000200502	0.001673144
Astrakhan'	Russia	0.000205301	1.38975E-05	0.000116175	0.000223128	1.54376E-05	0.000129497
Bashkortostan	Russia	0.000339033	0.000141444	0.001179864	0.000346896	0.000140064	0.001168359
Belgorod	Russia	0.000401341	0.000142548	0.001189177	0.000401341	0.000142548	0.001189177
Bryansk	Russia	0.000232089	0.000172749	0.001440454	0.000235666	0.000172751	0.001440487

		cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
id_name	**country**	**top soil**	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Buryat	Russia	0.000242053	0.000147796	0.001232982	0.000199143	8.18819E-05	0.000682718
Chechnya	Russia	0.000318623	9.75628E-05	0.000813902	0.000317671	9.55542E-05	0.00079713
Chelyabinsk	Russia	0.000329246	0.000120981	0.001009498	0.000325332	0.000108881	0.000908565
Chukotka	Russia	0.000249609	0.000183252	0.001528759			
Chuvash	Russia	0.000339689	0.00017181	0.001433328	0.000348118	0.000172066	0.001435475
City of St. Petersburg	Russia	0.000308936	0.000202713	0.00169122	0.000308396	0.000202833	0.001691841
Dagestan	Russia	0.000282528	9.71117E-05	0.000810172	0.000292187	0.000105414	0.000879499
Gorno-Altay	Russia	0.000242516	0.00014034	0.001170875	0.000238567	0.000121338	0.001012323
Ingush	Russia	0.000411094	0.000160989	0.001343141	0.000412256	0.000158988	0.001326445
Irkutsk	Russia	0.000310367	0.000138001	0.00115164	0.000290766	0.000106379	0.000887567
Ivanovo	Russia	0.000313132	0.000189866	0.001584044	0.000317681	0.000189893	0.001584245
Kabardin-Balkar	Russia	0.000356971	0.000173006	0.001443056	0.00035964	0.00017135	0.001429243
Kaliningrad	Russia	0.000264779	0.000196854	0.001643448	0.000264833	0.000196703	0.001642216
Kalmyk	Russia	0.000212248	2.25322E-05	0.000187227	0.000250531	3.43854E-05	0.000286597
Kaluga	Russia	0.00028038	0.000187984	0.001568208	0.000283446	0.000188027	0.001568586
Kamchatka	Russia	0.000221361	0.000218565	0.001822997			
Karachay-Cherkess	Russia	0.000347841	0.000206737	0.001724556	0.000357352	0.000203504	0.001697606
Karelia	Russia	0.000143017	0.000210106	0.001752017	0.000207013	0.000205301	0.001712329
Kemerovo	Russia	0.000313521	0.000149131	0.001244528	0.000362488	0.000148194	0.001236523
Khabarovsk	Russia	0.000333066	0.000218891	0.001826056	0.000423973	0.000205564	0.001714442
Khakass	Russia	0.000235258	0.000134127	0.001119216	0.000254506	0.000104169	0.000869305
Khanty-Mansiy	Russia	0.000322112	0.000204634	0.001706977	0.000400208	0.000189706	0.001582921
Kirov	Russia	0.000300839	0.000198508	0.001656931	0.000322202	0.000196988	0.001644238
Komi	Russia	0.000260851	0.000208123	0.001736464	0.000269872	0.000200506	0.00167352
Kostroma	Russia	0.000283966	0.000196535	0.001640395	0.000294004	0.000195328	0.001630462
Krasnodar	Russia	0.000439382	0.00014293	0.001192384	0.000443081	0.000133147	0.001110755
Krasnoyarsk	Russia	0.000321481	0.000194182	0.001620046	0.000334302	0.000135516	0.001130915
Kurgan	Russia	0.000377634	0.000115209	0.000961453	0.000377235	0.000114813	0.000958139
Kursk	Russia	0.000375505	0.0001665	0.001389121	0.000375505	0.0001665	0.001389121
Leningrad	Russia	0.000230044	0.000203318	0.001696239	0.000242418	0.000203207	0.001695269
Lipetsk	Russia	0.000392828	0.000152151	0.001269661	0.000395108	0.000152262	0.001270587
Maga Buryatdan	Russia	0.00019843	0.000182835	0.001525203			
Mariy-El	Russia	0.000309393	0.000185681	0.001549316	0.000335764	0.000186303	0.001554642
Mordovia	Russia	0.000346661	0.000166493	0.001387993	0.000355682	0.000166409	0.001387237
Moskovsskaya	Russia	0.0002874	0.000190398	0.001588494	0.000290022	0.000190461	0.001589
Moskva	Russia	0.000288843	0.000195265	0.001629098	0.000287849	0.000195104	0.001627703
Murmansk	Russia	0.00012797	0.000218497	0.001822724			

		cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
id_name	**country**	**top soil**	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Nenets	Russia	0.000242069	0.000207371	0.001729279			
Nizhegorod	Russia	0.000308213	0.000184872	0.001542699	0.000320439	0.000183353	0.001529798
North Ossetia	Russia	0.000367008	0.00018267	0.001523919	0.000368217	0.000180194	0.00150327
Novgorod	Russia	0.000233177	0.000197532	0.001648268	0.000244611	0.000197045	0.001644262
Novosibirsk	Russia	0.000383912	0.000116048	0.00096823	0.000375585	0.000112369	0.000937482
Omsk	Russia	0.000387032	0.000128048	0.001068599	0.000382876	0.000116434	0.000971976
Orel	Russia	0.000387138	0.000176118	0.001469774	0.000387481	0.000176108	0.001469694
Orenburg	Russia	0.000298276	7.67969E-05	0.000640692	0.000298507	7.6856E-05	0.00064118
Penza	Russia	0.000354549	0.000152501	0.001272207	0.000356247	0.000152416	0.001271493
Perm'	Russia	0.000310105	0.000200533	0.001672509	0.000350956	0.000191645	0.001598604
Primor'ye	Russia	0.000361609	0.000216003	0.001802001	0.000386749	0.00018791	0.001567719
Pskov	Russia	0.000209408	0.000195386	0.001630392	0.000220248	0.000194571	0.001623625
Rostov	Russia	0.000353407	8.55657E-05	0.000713642	0.000353661	8.56363E-05	0.000714226
Ryazan'	Russia	0.00033763	0.000167573	0.00139776	0.000345963	0.000166982	0.00139283
Sakha (Yakutia)	Russia	0.000250541	0.000142578	0.001189423	0.000231404	7.8068E-05	0.0006498
Sakhalin (Kuril Islands)	Russia	0.000222778	0.000244324	0.00203865	0.000245538	0.0002445	0.00204
Sakhalin (Main Island)	Russia	0.000273101	0.00022835	0.001905147	0.000257341	0.000235186	0.001962688
Samara	Russia	0.000392299	0.00013683	0.001141494	0.000393865	0.000136657	0.001140051
Saratov	Russia	0.00034513	9.89006E-05	0.000824932	0.00034603	9.92525E-05	0.000827864
Smolensk	Russia	0.000266204	0.000191521	0.001598271	0.000270816	0.000191422	0.001597493
Stavropol'	Russia	0.000331566	6.26794E-05	0.000522941	0.000335415	6.39398E-05	0.00053347
Sverdlovsk	Russia	0.000378552	0.00017848	0.00148914	0.000401603	0.000167263	0.001395445
Tambov	Russia	0.000394439	0.000143218	0.00119488	0.000399772	0.000142971	0.001192772
Tatarstan	Russia	0.000376976	0.000168398	0.001404278	0.000377595	0.000168437	0.001404597
Tomsk	Russia	0.000375479	0.00017906	0.001493658	0.000428436	0.000169227	0.001411614
Tula	Russia	0.000370234	0.00017995	0.001501685	0.000370252	0.000179949	0.001501676
Tuva	Russia	0.000226396	0.00013412	0.001118978	0.000235183	9.31425E-05	0.000777027
Tver'	Russia	0.000267407	0.000195572	0.001631489	0.000275732	0.000195273	0.001628999
Tyumen'	Russia	0.000403341	0.000162927	0.001359594	0.000427897	0.00014604	0.00121864
Udmurt	Russia	0.000333362	0.000182799	0.001525331	0.000338409	0.000181879	0.001517614
Ul'yanovsk	Russia	0.000346857	0.000154173	0.001286474	0.000348088	0.000154206	0.001286763
Vladimir	Russia	0.00028443	0.0001851	0.001544279	0.000291233	0.000185306	0.001546003
Volgograd	Russia	0.000314647	7.0706E-05	0.000590109	0.000317804	7.2171E-05	0.000602326
Vologda	Russia	0.000272876	0.000198765	0.001658579	0.000278921	0.000197955	0.001651968
Voronezh	Russia	0.000404328	0.00012273	0.001024206	0.00040569	0.000122608	0.001023189
Yamalo-Nenets	Russia	0.000352281	0.000218167	0.001819836			
Yaroslavl'	Russia	0.000313868	0.000192015	0.001602454	0.000316975	0.000191964	0.001601976

		cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
id_name	**country**	**top soil**	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Yevrey	Russia	0.00038711	0.000180711	0.00150745	0.000405553	0.000172948	0.001442718
Zabaykalsky	Russia	0.00027498	0.000120035	0.001001375	0.000243205	8.64693E-05	0.000721372
Rwanda	Rwanda	0.000472753	0.00012297	0.001025992	0.000469478	0.00012162	0.00101472
Saba	Saba	0.00054074	0.000170633	0.001422667			
Saint Eustatius	Saint Eustatius	0.000561821	0.000182342	0.001521053			
Ascension	Saint Helena	0.000200061	1.48571E-06	1.26667E-05			
Saint Helena	Saint Helena	0.000600929	0.000165747	0.001383014			
Tristan da Cunha	Saint Helena	0.000435482	0.000244227	0.002037963			
Saint Kitts and Nevis	Saint Kitts and Nevis	0.000650151	0.000209153	0.001744875			
Saint Lucia	Saint Lucia	0.000739158	0.000220678	0.001841467			
Saint Pierre and Miquelon	Saint Pierre and Miquelon	0.000310305	0.000242234	0.002022727			
Saint Vincent and The Grenadines	Saint Vincent and The Grenadines	0.000726228	0.000229286	0.001912933			
Saint-Barthélemy	Saint-Barthélemy	0.000515	0.000155086	0.001295238			
Saint-Martin	Saint-Martin	0.000515688	0.000150195	0.001252619			
Samoa	Samoa	0.000418042	0.000244089	0.002036592			
San Marino	San Marino	0.000536056	0.000164332	0.001371215	0.000536056	0.000164332	0.001371215
Principe	Sao Tome and Principe	0.00068756	0.000213375	0.001780405			
Sao Tome	Sao Tome and Principe	0.000674778	0.000206032	0.001718858			
Saudi Arabia	Saudi Arabia	3.95274E-05	2.14311E-08	1.83478E-07	8.80276E-05	6.88928E-07	5.8937E-06
Senegal	Senegal	0.000173777	3.97739E-05	0.000331839	0.000166841	3.78883E-05	0.000316078
Serbia	Serbia	0.00036655	0.000137705	0.001149032	0.000366928	0.000136832	0.001141755
Aldabra	Seychelles	0.000487667	0.000153883	0.001283667			
Seychelles	Seychelles	0.000743078	0.000241175	0.002011399			
Sierra Leone	Sierra Leone	0.000404961	0.000161557	0.001347978	0.000403419	0.000157484	0.001314097
Singapore	Singapore	0.000692307	0.000244498	0.002039983	0.000694492	0.000244497	0.002039979
Sint Maarten	Sint Maarten	0.00051708	0.000149484	0.001246939			
Slovakia	Slovakia	0.000326043	0.000172319	0.001437539	0.000329451	0.000164662	0.001373662
Slovenia	Slovenia	0.000445565	0.000222504	0.001856041	0.000445491	0.000219265	0.001828938
Santa Cruz Island	Solomon Islands	0.000763633	0.0002445	0.00204			
South Solomons	Solomon Islands	0.000732288	0.00024356	0.002032116			
Somalia	Somalia	0.000134738	2.12829E-06	1.78287E-05	0.000212272	6.04848E-06	5.05997E-05
Eastern Cape	South Africa	0.000248371	4.89672E-05	0.000408699	0.000261958	5.57587E-05	0.000465316
Gauteng	South Africa	0.000244865	4.42915E-05	0.000369397	0.000241888	4.31571E-05	0.000359868
KwaZulu-Natal	South Africa	0.000365211	9.26971E-05	0.000773346	0.000365859	9.25723E-05	0.000772309
Limpopo	South Africa	0.000190952	2.87811E-05	0.000240158	0.000187569	2.75433E-05	0.000229834
Mpumalanga	South Africa	0.00031568	6.55712E-05	0.00054716	0.000311277	6.3584E-05	0.000530577
North West	South Africa	0.00014276	1.6549E-05	0.000138136	0.000149745	1.81436E-05	0.000151415

		cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
id_name	**country**	**top soil**	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Northern Cape	South Africa	8.17781E-05	8.97917E-07	7.61848E-06	9.18787E-05	6.71089E-07	5.71475E-06
Orange Free State	South Africa	0.000212564	3.01161E-05	0.000251388	0.00021929	3.39065E-05	0.000282952
Prince Edward Islands	South Africa	0.000228962	0.0002445	0.00204			
Western Cape	South Africa	0.000144028	2.33069E-05	0.000194576	0.000149353	2.54186E-05	0.000212207
South Georgia and the South Sandwich Islands	South Georgia and the South Sandwich Islands	0.000221097	0.0002445	0.00204			
South Sandwich Island	South Georgia and the South Sandwich Islands						
South Korea	South Korea	0.000392199	0.000219152	0.001828485	0.000392471	0.000218372	0.001821978
South Sudan	South Sudan	0.000319027	6.66862E-05	0.000556424	0.000315717	6.41094E-05	0.000534932
Baleares	Spain	0.000329722	0.000106166	0.000885879	0.000332648	0.000108083	0.000901866
Canary Islands	Spain	0.000217438	3.05806E-05	0.000255248			
Spain (Mainland)	Spain	0.000276318	9.2661E-05	0.000773137	0.000271697	8.6126E-05	0.000718629
Spanish North African Territories	Spain	0.000288816	7.57131E-05	0.000631967			
Spratly islands	Spratly islands						
Sri Lanka	Sri Lanka	0.000546652	0.000172221	0.001436659	0.000548596	0.000173092	0.001443941
Sudan	Sudan	0.000107082	7.9695E-06	6.65143E-05	0.000229524	2.10713E-05	0.000175772
Suriname	Suriname	0.0005388	0.000200806	0.001675216	0.000529953	0.00020388	0.001700958
Svalbard and Jan Mayen	Svalbard and Jan Mayen	0.000299694	0.000231887	0.001934847			
Swaziland	Swaziland	0.000347727	8.06504E-05	0.000672915	0.000345468	8.06094E-05	0.000672593
Sweden	Sweden	0.000147782	0.000208731	0.001741188	0.000237171	0.00019618	0.00163641
Switzerland	Switzerland	0.000338418	0.000234969	0.001960477	0.000363692	0.000232057	0.001936179
Syria	Syria	0.000177144	1.55304E-05	0.000129663	0.000267409	3.51664E-05	0.00029354
Kin-Men	Taiwan	0.000369169	0.000162127	0.001352388	0.000371218	0.0001613	0.001345536
Ma-tsu-pai-chúan	Taiwan	0.000494275	0.000226925	0.00189375			
Taiwan	Taiwan	0.000483341	0.000212295	0.001771159	0.000482035	0.000212281	0.001771043
Tajikistan	Tajikistan	0.000231798	9.06436E-05	0.000756387	0.000247478	9.11907E-05	0.000760898
Tanzania	Tanzania	0.000314631	8.36091E-05	0.000697664	0.000319256	8.36515E-05	0.000698029
Thailand	Thailand	0.000389188	0.000128507	0.001072361	0.000388551	0.000128195	0.001069759
Togo	Togo	0.000234521	0.000100768	0.000841026	0.000235004	0.000100795	0.00084125
Tokelau	Tokelau						
Tonga	Tonga	0.000586205	0.000237101	0.001977585			
Trinidad and Tobago	Trinidad and Tobago	0.000711471	0.000205645	0.001715413	0.000715895	0.000206422	0.001721854
Tunisia	Tunisia	0.000137369	1.2518E-05	0.000104494	0.000308847	5.29151E-05	0.000441481
Turkey	Turkey	0.000311517	8.86789E-05	0.000739935	0.000311094	8.70908E-05	0.000726682
Turkey-in-Europe	Turkey	0.000373431	0.000108639	0.000906899	0.000373021	0.000107318	0.000895944
Turkmenistan	Turkmenistan	0.000110976	3.12112E-06	2.60821E-05	0.000143654	1.09436E-05	9.12842E-05
Turks and Caicos	Turks and Caicos	0.000394337	6.90062E-05	0.000576101			

		cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
id_name	**country**	**top soil**	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Islands	Islands						
Tuvalu	Tuvalu	0.00066755	0.0002445	0.00204			
Uganda	Uganda	0.000441507	0.000102963	0.000859027	0.000434287	0.00010088	0.00084164
Krym	Ukraine	0.000331006	8.46298E-05	0.000705787	0.000332372	8.45384E-05	0.000705011
Ukraine	Ukraine	0.000302684	0.000135036	0.001126563	0.000303053	0.000133768	0.001115993
United Arab Emirates	United Arab Emirates	3.07212E-05	5.19459E-08	4.38635E-07	6.1827E-05	6.78773E-08	6.16255E-07
Great Britain	United Kingdom	0.000320286	0.000209023	0.001743761	0.000346522	0.000203749	0.001699797
Northern Ireland	United Kingdom	0.000333986	0.000227713	0.001900089	0.000336176	0.000227548	0.001898694
Alabama	United States	0.000329068	0.000180702	0.001507268	0.000328496	0.000180543	0.001505945
Alaska	United States	0.000209263	0.00016789	0.001400656			
Aleutian Islands	United States	0.000216407	0.00024283	0.002026523			
Arizona	United States	0.000151572	1.22646E-05	0.000102565	0.000144948	8.68104E-06	7.27101E-05
Arkansas	United States	0.000310772	0.000178004	0.001485161	0.000313107	0.000177973	0.001484929
California	United States	0.000181974	6.13316E-05	0.000511807	0.000179441	5.09078E-05	0.000424862
Colorado	United States	0.000197291	4.73056E-05	0.000395039	0.000196916	3.86052E-05	0.000322504
Connecticut	United States	0.000165251	0.000205182	0.001711287	0.000165444	0.000205058	0.001710255
Delaware	United States	0.000178329	0.000185705	0.001549415	0.000173723	0.000185537	0.001548027
District of Columbia	United States	0.000317991	0.000178338	0.001486979	0.000308275	0.000177325	0.00147875
Florida	United States	0.000117278	0.000167261	0.001395283	0.000109053	0.000164813	0.001374873
Georgia (US)	United States	0.000262792	0.000165459	0.001380569	0.00026195	0.000164563	0.001373082
Hawaii	United States	0.000403945	0.000178821	0.001491933			
Idaho	United States	0.000173088	7.87067E-05	0.000656728	0.000183132	6.24649E-05	0.000521225
Illinois	United States	0.000374041	0.000176543	0.001472782	0.000373417	0.000176433	0.001471865
Indiana	United States	0.000346924	0.000183274	0.001529204	0.000346944	0.000183259	0.001529089
Iowa	United States	0.000396557	0.00015803	0.001318597	0.000396558	0.000158026	0.001318559
Kansas	United States	0.000303551	8.31496E-05	0.000693866	0.000303434	8.30732E-05	0.000693228
Kentucky	United States	0.000342506	0.000185246	0.00154561	0.000344427	0.000185191	0.00154517
Louisiana	United States	0.000400621	0.000188581	0.001573642	0.000393924	0.000187562	0.001565206
Maine	United States	0.000199638	0.000207569	0.001731285	0.000195449	0.000207015	0.001726589
Maryland	United States	0.000267647	0.000183931	0.001534353	0.000268665	0.000184092	0.001535688
Massachusetts	United States	0.000147592	0.000202416	0.001688422	0.000146187	0.000202257	0.001687139
Michigan	United States	0.000222644	0.000181028	0.00151036	0.000229976	0.000179926	0.001501142
Minnesota	United States	0.000281181	0.000146754	0.001224201	0.000285245	0.000142752	0.001190801
Mississippi	United States	0.000344518	0.000182123	0.001519459	0.000345	0.000181873	0.001517385
Missouri	United States	0.000351704	0.000172132	0.001435943	0.000351989	0.000172147	0.00143607
Montana	United States	0.000228356	5.26133E-05	0.000439085	0.000235907	4.32298E-05	0.000360834
Nebraska	United States	0.000220778	6.5895E-05	0.00054984	0.000220766	6.58905E-05	0.000549803

		cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
id_name	**country**	**top soil**	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Nevada	United States	0.000121742	1.02652E-05	8.58471E-05	0.000121939	1.03721E-05	8.67454E-05
New Hampshire	United States	0.000131038	0.000205504	0.001714361	0.000133047	0.000205339	0.001712996
New Jersey	United States	0.000206964	0.000197008	0.001643573	0.00020277	0.000195937	0.001634701
New Mexico	United States	0.000164774	1.19792E-05	0.000100494	0.000161608	9.2548E-06	7.7825E-05
New York	United States	0.000245101	0.000200864	0.00167565	0.00025844	0.00019907	0.001660753
North Carolina	United States	0.000311459	0.000186799	0.001558823	0.000310782	0.000185192	0.001545456
North Dakota	United States	0.000264645	6.02752E-05	0.00050292	0.000264704	6.02975E-05	0.000503109
Ohio	United States	0.000388876	0.000179353	0.001496291	0.000389537	0.0001793	0.001495858
Oklahoma	United States	0.000262693	0.000103025	0.000859729	0.000262313	0.000102471	0.000855109
Oregon	United States	0.000219379	8.85903E-05	0.000739202	0.000203929	6.19429E-05	0.000516849
Pennsylvania	United States	0.000317096	0.000194317	0.001621085	0.000321383	0.000193735	0.001616227
Rhode Island	United States	0.000133446	0.000202935	0.001692884	0.000128916	0.00020294	0.001692822
South Carolina	United States	0.000314337	0.00017148	0.001431155	0.000313149	0.000170807	0.001425555
South Dakota	United States	0.000280983	5.18897E-05	0.00043308	0.000281643	5.15124E-05	0.000429926
Tennessee	United States	0.000336718	0.000186983	0.001559858	0.00033622	0.00018645	0.001555425
Texas	United States	0.000259885	5.78563E-05	0.0004827	0.00026398	5.99345E-05	0.000500032
Utah	United States	0.000160414	2.66914E-05	0.000222899	0.00016159	2.67002E-05	0.000222993
Vermont	United States	0.000161613	0.000209114	0.001744726	0.00016469	0.000208771	0.00174188
Virginia	United States	0.000318091	0.000178127	0.001485658	0.000320118	0.000177567	0.001480967
Washington	United States	0.000155586	0.000120714	0.001007105	0.000151164	8.55658E-05	0.000713927
West Virginia	United States	0.000344686	0.000189848	0.00158386	0.000348417	0.000188537	0.00157288
Wisconsin	United States	0.000244934	0.000182985	0.001526788	0.000249844	0.000182307	0.00152115
Wyoming	United States	0.000190459	3.80241E-05	0.000317524	0.000188683	3.00052E-05	0.000250647
Howland-Baker Island	United States Minor Outlying Islands						
Johnston Island	United States Minor Outlying Islands						
Midway Island	United States Minor Outlying Islands	0.00041585	0.00019665	0.00164			
U.S. Line Island	United States Minor Outlying Islands						
Wake Island	United States Minor Outlying Islands	0.0004864	0.000126767	0.001056667			
Uruguay	Uruguay	0.00045576	0.00017671	0.001473729	0.000448621	0.000176587	0.001472753
Uzbekistan	Uzbekistan	0.000150571	1.24277E-05	0.000103724	0.000206657	3.29732E-05	0.000275193
Vanuatu	Vanuatu	0.000726171	0.000237481	0.001981256			
Vatican City	Vatican City	0.0004259	0.0001406	0.00117	0.0004259	0.0001406	0.00117
Aves Island	Venezuela						
Venezuela	Venezuela	0.000465317	0.000159969	0.001334618	0.00043449	0.000139396	0.001162951
Venezuelan Antilles	Venezuela	0.000255573	2.31911E-05	0.000193673			
Vietnam	Vietnam	0.000511761	0.000168802	0.001408173	0.000512064	0.000168855	0.001408609
Virgin Islands, U.S.	Virgin Islands, U.S.	0.000537998	0.000150991	0.001259588			

id_name	country	cf_geo_units (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_geo_units_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
		top soil	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Wallis and Futuna	Wallis and Futuna	0.000596506	0.0002445	0.00204			
Western Sahara	Western Sahara	4.52425E-05	0	0			
North Yemen	Yemen	9.91336E-05	1.14464E-06	9.72638E-06	0.000143356	3.13669E-06	2.63714E-05
Socotra	Yemen	0.000115133	0	0	0.000122102	0	0
South Yemen	Yemen	3.40067E-05	2.95458E-08	2.55208E-07	8.6429E-05	7.68221E-07	6.53614E-06
Yemen (new)	Yemen	1.55289E-06	0	0			
Zambia	Zambia	0.000268024	8.53383E-05	0.000712165	0.000268882	8.61578E-05	0.000719003
Zimbabwe	Zimbabwe	0.000181222	4.32041E-05	0.000360535	0.00018079	4.22441E-05	0.000352505

	cf_countries (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_countries_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
country	**top soil**	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Afghanistan	0.00015212	2.94721E-05	0.000245867	0.00018168	3.81548E-05	0.000318309
Albania	0.000463629	0.000181132	0.001511115	0.000463345	0.000181255	0.001512132
Algeria	5.56569E-05	4.47306E-06	3.73515E-05	0.000307796	7.12147E-05	0.000594278
American Samoa	0.00056441	0.0002445	0.00204			
Andorra	0.000242049	0.000238198	0.001987114	0.000241081	0.000238533	0.001989857
Angola	0.000220011	8.55347E-05	0.000713624	0.00022628	8.86089E-05	0.000739248
Anguilla	0.000475617	0.000136233	0.001135454			
Antarctica						
Antigua and Barbuda	0.000538757	0.000147784	0.001233688			
Argentina	0.00020372	4.82275E-05	0.00040254	0.000253145	6.9186E-05	0.000577345
Armenia	0.000283569	8.83797E-05	0.000737459	0.000283685	8.86344E-05	0.000739584
Aruba	0.000248256	1.71716E-05	0.000143249			
Australia	0.000171653	2.54087E-05	0.000212129	0.000233755	5.03893E-05	0.000420538
Austria	0.000315099	0.000215855	0.001800844	0.000326594	0.000199931	0.001668014
Azerbaijan	0.000292858	6.53274E-05	0.000545105	0.000293456	6.53082E-05	0.000544952
Bahamas	0.000411634	0.000139167	0.00116146			
Bahrain	7.56019E-05	0	0	0.000106325	0	0
Bangladesh	0.000450804	0.000163175	0.001361374	0.000450079	0.00016321	0.001361627
Barbados	0.000627781	0.000159086	0.001327936			
Belarus	0.000163596	0.000177975	0.001484809	0.000164329	0.000177752	0.001482943
Belgium	0.000258387	0.000198721	0.00165763	0.000257625	0.000198601	0.001656632
Belize	0.000645804	0.000202767	0.001691431	0.000645384	0.000200151	0.001669606
Benin	0.000219014	8.36755E-05	0.000698292	0.000218727	8.37097E-05	0.000698565
Bermuda	0.000474793	0.000234029	0.001954643			
Bhutan	0.000288309	0.000149536	0.001247541	0.000288448	0.00014942	0.001246576
Bolivia	0.000307564	9.88341E-05	0.000824646	0.000302819	9.57933E-05	0.000799261
Bonaire	0.000294312	2.85167E-05	0.00023965			
Bosnia and Herzegovina	0.00043961	0.000197287	0.001645937	0.00043991	0.000196662	0.001640755
Botswana	7.04177E-05	4.99392E-06	4.16472E-05	7.58484E-05	5.38098E-06	4.48088E-05
Brazil	0.000440367	0.000154033	0.001285118	0.000419208	0.000137448	0.001146761
British Indian Ocean Territory	0.000817955	0.0002445	0.00204			
British Virgin Islands	0.000560194	0.0001656	0.001381417			
Brunei	0.000536609	0.000244459	0.002039688	0.000538524	0.000244467	0.002039746
Bulgaria	0.00035008	0.000112435	0.000938201	0.000353697	0.000109761	0.000915914
Burkina Faso	0.000183238	4.81496E-05	0.000401698	0.000181946	4.70746E-05	0.000392721
Burundi	0.000478819	0.000129398	0.001079432	0.000482103	0.00012997	0.001084192
Cambodia	0.000427982	0.00014602	0.001218377	0.00042788	0.000146105	0.001219067
Cameroon	0.000497704	0.000145348	0.001212803	0.0004111	0.000123673	0.001031988
Canada	0.000272365	0.000176721	0.001474349	0.000289456	0.000142699	0.001190563
Cape Verde	0.000232483	1.88639E-05	0.000157428			
Cayman Islands	0.000626374	0.000168934	0.001408429			
Central African Republic	0.000397574	0.000115115	0.00096045	0.000382848	0.0001112	0.000927757

	cf_countries (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_countries_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
country	**top soil**	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Chad	0.000103387	1.6306E-05	0.000136079	0.00019072	3.51762E-05	0.000293564
Chile	0.000203146	0.000110124	0.000918782	0.000248226	0.000133672	0.001115254
China	0.000242027	9.25657E-05	0.000772366	0.000280094	0.000114359	0.000954173
Christmas Island	0.000770877	0.000215981	0.001803023			
Clipperton Island						
Cocos (Keeling) Islands	0.00072368	0.00022656	0.00189			
Colombia	0.00046606	0.000208289	0.001737678	0.000497944	0.000200105	0.001669386
Comoros	0.000711597	0.000211513	0.001764342			
Cook Islands	0.000654353	0.000239198	0.001996193			
Costa Rica	0.000559258	0.000203279	0.001696037	0.000558315	0.000198775	0.001658437
Cote d'Ivoire	0.000309574	0.000122116	0.001018684	0.0003066	0.000120402	0.001004374
Croatia	0.000457233	0.000186883	0.001559085	0.000449109	0.000184569	0.001539803
Cuba	0.000594797	0.000147044	0.001226868	0.000606999	0.000147726	0.00123261
Curacao	0.000340674	4.26854E-05	0.000357205			
Cyprus	0.000261852	5.7708E-05	0.00048172	0.000263134	5.38014E-05	0.000449109
Czech Republic	0.000282379	0.000169398	0.00141346	0.00028365	0.000166929	0.001392885
Democratic Republic of the Congo	0.000467431	0.000168375	0.001404604	0.000368917	0.000140139	0.001169083
Denmark	0.000217313	0.000208196	0.001736546	0.000211304	0.000208397	0.001738215
Djibouti	9.48046E-05	2.19065E-09	2.34146E-08	0.000116817	0	0
Dominica	0.000729418	0.000235696	0.001966435			
Dominican Republic	0.000519843	0.000147423	0.001229944	0.000521196	0.000147899	0.001233912
East Timor	0.000430856	0.000153001	0.00127652	0.000433492	0.000154399	0.001288183
Ecuador	0.000454799	0.000176486	0.001472396	0.000449282	0.00017261	0.001440107
Egypt	4.05878E-05	1.90799E-06	1.59127E-05	0.000215241	3.63118E-05	0.000302723
El Salvador	0.000500483	0.000134838	0.001124742	0.000500451	0.000134922	0.001125451
Equatorial Guinea	0.000694265	0.000212851	0.001775634	0.000638207	0.000212529	0.001773219
Eritrea	0.000144196	8.74329E-06	7.29503E-05	0.000205648	1.94872E-05	0.00016253
Estonia	0.000253935	0.000200345	0.001671381	0.000254379	0.000200519	0.00167285
Ethiopia	0.000333038	5.23184E-05	0.00043669	0.000383667	6.37183E-05	0.000531754
Falkland Islands	0.000309059	0.000187611	0.00156512			
Faroe Islands	0.000214276	0.000244252	0.002037477			
Fiji	0.0007241	0.00024176	0.00201702			
Finland	0.000152576	0.000204508	0.001706383	0.000231366	0.000199046	0.001661174
France	0.000355437	0.000174254	0.001453656	0.000358393	0.00017296	0.001442863
French Guiana	0.000622047	0.000212507	0.001772768	0.000621721	0.000211505	0.001764516
French Polynesia	0.000664438	0.000213586	0.001781851			
French Southern Territories	0.000258512	0.000226444	0.001889331			
Gabon	0.000590605	0.000186057	0.00155245	0.00050731	0.000186677	0.001557898
Gambia	0.000199646	5.83867E-05	0.000487145	0.000196197	5.78678E-05	0.00048278
Georgia	0.000364849	0.000184872	0.001542243	0.00036322	0.000181086	0.001510631
Germany	0.000262746	0.000183019	0.001526686	0.000260846	0.000181803	0.001516546
Ghana	0.000259787	0.000120612	0.001006291	0.000258087	0.00012055	0.001005773
Gibraltar	0.000341883	0.00011855	0.000988333			

	cf_countries (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_countries_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
country	**top soil**	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Greece	0.000330552	0.000108741	0.000907368	0.000329355	0.000107973	0.000900961
Greenland	0.000273439	0.00022045	0.001839218			
Grenada	0.000697452	0.000213968	0.001785315			
Guadeloupe	0.000687681	0.000208876	0.001742572			
Guam	0.000787344	0.000228264	0.001904837			
Guatemala	0.000579756	0.000175226	0.001461935	0.000578623	0.000175262	0.00146226
Guinea	0.000390822	0.00011714	0.000977417	0.000398678	0.000118752	0.000990915
Guinea-Bissau	0.000327739	0.000102104	0.000851969	0.000328456	0.000101121	0.000843657
Guyana	0.000513067	0.000190174	0.001586622	0.000498565	0.000190197	0.001586786
Haiti	0.000533358	0.000164997	0.001376435	0.000537641	0.000167383	0.001396343
Heard Island and McDonald Islands	0.000241231	0.000233775	0.00194875			
Honduras	0.000558075	0.000168929	0.001409265	0.000549912	0.000165075	0.001377138
Hong Kong	0.000431648	0.000208293	0.001737695	0.00043267	0.000198617	0.001657826
Hungary	0.000303024	0.000111215	0.000927975	0.000302894	0.000110646	0.00092322
Iceland	0.000164372	0.000240015	0.00200255			
India	0.000369877	9.13072E-05	0.000761812	0.000374248	9.2181E-05	0.000769094
Indonesia	0.000644416	0.000230535	0.001923397	0.000646451	0.000231031	0.001927538
Iran	0.000133088	1.00373E-05	8.37688E-05	0.000198992	2.19132E-05	0.000182828
Iraq	0.000137983	1.13876E-05	9.50992E-05	0.000217353	2.62868E-05	0.000219548
Ireland	0.000326857	0.000222651	0.00185739	0.000336111	0.000221234	0.001845533
Israel	0.000182383	2.23169E-05	0.000186386	0.000276977	4.77896E-05	0.000398886
Italy	0.000395747	0.000164036	0.001368406	0.000403092	0.000160435	0.001338373
Jamaica	0.000753135	0.000212069	0.001769123	0.000755994	0.000213065	0.00177741
Japan	0.000377338	0.000240062	0.00200278	0.000380175	0.000239923	0.002001641
Jordan	0.000109362	2.28446E-06	1.91362E-05	0.000208643	1.46393E-05	0.000122346
Kazakhstan	0.000213682	2.91621E-05	0.000243463	0.000251639	5.08127E-05	0.000424148
Kenya	0.000254356	3.0357E-05	0.000253407	0.000270118	3.35861E-05	0.000280338
Kiribati	0.000592592	0.000193268	0.00161275			
Kosovo	0.00038429	0.000168843	0.001408362	0.000384581	0.000169063	0.001410193
Kuwait	6.42017E-05	0	0	7.76229E-05	0	0
Kyrgyzstan	0.000230537	8.33618E-05	0.000695566	0.000232392	8.35635E-05	0.00069724
Laos	0.000427231	0.000144297	0.001203932	0.000426186	0.000144133	0.001202578
Latvia	0.00023315	0.000201054	0.001676976	0.000234628	0.000200975	0.001676292
Lebanon	0.000374049	0.000102942	0.000858937	0.000376464	0.000102403	0.000854439
Lesotho	0.00030443	9.46315E-05	0.000789528	0.000306766	9.46817E-05	0.000789948
Liberia	0.000460864	0.000194752	0.001624715	0.000461043	0.000198411	0.001655193
Libya	3.10396E-05	4.04067E-07	3.3752E-06	0.000194173	2.32901E-05	0.000194412
Liechtenstein	0.000361841	0.000240217	0.002004295	0.000357026	0.000240508	0.002006689
Lithuania	0.00021276	0.000192506	0.001605915	0.000215172	0.000192643	0.00160707
Luxembourg	0.00037404	0.000196005	0.001635363	0.00037404	0.000196005	0.001635363
Macao	0.000398937	0.0002041	0.0017			
Macedonia	0.000304595	0.000110858	0.000925038	0.000304127	0.000109807	0.000916286
Madagascar	0.000337735	0.000112256	0.00093671	0.000335674	0.000113601	0.000947966

country	cf_countries (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_countries_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
	top soil	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Malawi	0.000302413	9.94932E-05	0.000830179	0.000298102	9.82772E-05	0.000820008
Malaysia	0.000629256	0.000238803	0.001992296	0.00063057	0.000238921	0.00199329
Maldives	0.000895467	0.000241367	0.002013333			
Mali	8.65746E-05	1.53505E-05	0.000128132	0.00017321	3.78367E-05	0.000315767
Malta	0.000306704	8.3686E-05	0.000698155			
Marshall Islands	0.000765412	0.000234225	0.001955			
Martinique	0.000703286	0.000224145	0.001869959			
Mauritania	3.777E-05	2.52423E-07	2.13846E-06	6.91131E-05	1.89142E-06	1.60028E-05
Mauritius	0.000758795	0.000216185	0.001804237			
Mayotte	0.000503049	0.000147122	0.001228035			
Mexico	0.000350084	5.4251E-05	0.00045275	0.000358876	5.67348E-05	0.000473473
Micronesia	0.000733447	0.0002445	0.00204			
Moldova	0.000373805	0.000108823	0.000908004	0.000373805	0.000108823	0.000908004
Monaco	0.000465274	0.000180668	0.001507368	0.000478455	0.000184873	0.001542727
Mongolia	0.000154142	2.67447E-05	0.000223307	0.000188167	4.20673E-05	0.000351112
Montenegro	0.00042527	0.000211756	0.001766796	0.000422996	0.000212188	0.001770409
Montserrat	0.000648921	0.000222423	0.001855664			
Morocco	0.000182478	2.22554E-05	0.0001858	0.000264233	4.46867E-05	0.000372872
Mozambique	0.000254216	7.93353E-05	0.000661929	0.000255571	7.93964E-05	0.000662429
Myanmar	0.000446091	0.000145404	0.001213238	0.000443956	0.000145214	0.001211652
Namibia	5.64517E-05	5.19746E-06	4.33073E-05	7.47887E-05	7.60884E-06	6.33095E-05
Nauru	0.000604041	0.0002364	0.00197			
Nepal	0.000333819	0.000151435	0.001263285	0.000334493	0.000151513	0.001263945
Netherlands	0.000273662	0.000199796	0.001666504	0.000269456	0.000199452	0.001663609
New Caledonia	0.000532871	0.000211862	0.001767251			
New Zealand	0.000403154	0.000214897	0.001792913	0.000411719	0.000188425	0.001571979
Nicaragua	0.000571348	0.000185643	0.001549011	0.000567889	0.000184005	0.001535368
Niger	3.35101E-05	2.05957E-06	1.71546E-05	6.35268E-05	8.27157E-06	6.8851E-05
Nigeria	0.000220015	9.09257E-05	0.000758616	0.000217081	8.96143E-05	0.00074767
Niue	0.000625353	0.000244484	0.002039826			
Norfolk Island						
North Korea	0.000322154	0.000209998	0.001751737	0.000322975	0.0002094	0.001746765
Northern Mariana Islands	0.00081009	0.000228104	0.00190377			
Norway	0.000152888	0.000231045	0.001927319	0.000218674	0.000227326	0.001896528
Oman	3.5263E-05	1.64759E-08	1.36888E-07	9.19167E-05	3.76749E-07	3.10776E-06
Pakistan	0.000144158	1.93699E-05	0.000161585	0.000174912	2.73938E-05	0.000228529
Palau	0.000870728	0.0002445	0.00204			
Palestine	0.000248801	3.76973E-05	0.000314625	0.000262668	4.18236E-05	0.000349094
Panama	0.000530881	0.000195813	0.001633673	0.000528698	0.000192351	0.001604806
Papua New Guinea	0.000622581	0.000234498	0.001956419	0.000620715	0.000234445	0.001955975
Paraguay	0.000333167	0.000102401	0.000854482	0.000352386	0.000112433	0.000938129
Peru	0.000385006	0.000150919	0.00125903	0.000347403	0.000121445	0.001013168
Philippines	0.000584897	0.000211124	0.001761403	0.000586313	0.000211234	0.001762331

	cf_countries (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_countries_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
country	**top soil**	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Pitcairn Islands	0.000641226	0.000237753	0.001982791			
Poland	0.000162218	0.000158531	0.001322845	0.000160286	0.00015758	0.001314918
Portugal	0.000275273	0.000128789	0.001074377	0.000267505	0.000122358	0.001020712
Puerto Rico	0.00073687	0.000196297	0.001637607	0.000749683	0.000199628	0.001665402
Qatar	5.3503E-05	0	0			
Republic of Congo	0.000514893	0.000180144	0.001502789	0.000479645	0.00018215	0.001519795
Reunion	0.000721343	0.000219946	0.001834847			
Romania	0.000342628	0.000126021	0.001051302	0.000346796	0.000118231	0.000986331
Russia	0.000289766	0.000173017	0.001443398	0.000336457	0.000142052	0.001185193
Rwanda	0.000472753	0.00012297	0.001025992	0.000469478	0.00012162	0.00101472
Saba	0.00054074	0.000170633	0.001422667			
Saint-Barthtlemy	0.000515	0.000155086	0.001295238			
Saint-Martin	0.000515688	0.000150195	0.001252619			
Saint Eustatius	0.000561821	0.000182342	0.001521053			
Saint Helena	0.000433911	0.000141314	0.001179248			
Saint Kitts and Nevis	0.000650151	0.000209153	0.001744875			
Saint Lucia	0.000739158	0.000220678	0.001841467			
Saint Pierre and Miquelon	0.000310305	0.000242234	0.002022727			
Saint Vincent and The Grenadines	0.000726228	0.000229286	0.001912933			
Samoa	0.000418042	0.000244089	0.002036592			
San Marino	0.000536056	0.000164332	0.001371215	0.000536056	0.000164332	0.001371215
Sao Tome and Principe	0.000676536	0.000207042	0.001727323			
Saudi Arabia	3.95274E-05	2.14311E-08	1.83478E-07	8.80276E-05	6.88928E-07	5.8937E-06
Senegal	0.000173777	3.97739E-05	0.000331839	0.000166841	3.78883E-05	0.000316078
Serbia	0.00036655	0.000137705	0.001149032	0.000366928	0.000136832	0.001141755
Seychelles	0.000708718	0.000229431	0.001913498			
Sierra Leone	0.000404961	0.000161557	0.001347978	0.000403419	0.000157484	0.001314097
Singapore	0.000692307	0.000244498	0.002039983	0.000694492	0.000244497	0.002039979
Sint Maarten	0.00051708	0.000149484	0.001246939			
Slovakia	0.000326043	0.000172319	0.001437539	0.000329451	0.000164662	0.001373662
Slovenia	0.000445565	0.000222504	0.001856041	0.000445491	0.000219265	0.001828938
Solomon Islands	0.000732865	0.000243578	0.002032261			
Somalia	0.000134738	2.12829E-06	1.78287E-05	0.000212272	6.04848E-06	5.05997E-05
South Africa	0.000180844	2.91165E-05	0.000243021	0.000205375	3.61305E-05	0.000301513
South Georgia and the South Sandwich Islands	0.000221097	0.0002445	0.00204			
South Korea	0.000392199	0.000219152	0.001828485	0.000392471	0.000218372	0.001821978
South Sudan	0.000319027	6.66862E-05	0.000556424	0.000315717	6.41094E-05	0.000534932
Spain	0.000276133	9.20639E-05	0.000768158	0.000272244	8.63231E-05	0.000720275
Spratly islands						
Sri Lanka	0.000546652	0.000172221	0.001436659	0.000548596	0.000173092	0.001443941
Sudan	0.000107082	7.9695E-06	6.65143E-05	0.000229524	2.10713E-05	0.000175772
Suriname	0.0005388	0.000200806	0.001675216	0.000529953	0.00020388	0.001700958

	cf_countries (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer			cf_countries_crop-area (see Chapter 11.3) Unit: average yearly loss (in %) over 100 years per corrected ton kilometer		
country	**top soil**	**mid soil**	**bottom soil**	**top soil**	**mid soil**	**bottom soil**
Svalbard and Jan Mayen	0.000299694	0.000231887	0.001934847			
Swaziland	0.000347727	8.06504E-05	0.000672915	0.000345468	8.06094E-05	0.000672593
Sweden	0.000147782	0.000208731	0.001741188	0.000237171	0.00019618	0.00163641
Switzerland	0.000338418	0.000234969	0.001960477	0.000363692	0.000232057	0.001936179
Syria	0.000177144	1.55304E-05	0.000129663	0.000267409	3.51664E-05	0.00029354
Taiwan	0.000483003	0.000212148	0.001769934	0.000481892	0.000212216	0.001770496
Tajikistan	0.000231798	9.06436E-05	0.000756387	0.000247478	9.11907E-05	0.000760898
Tanzania	0.000314631	8.36091E-05	0.000697664	0.000319256	8.36515E-05	0.000698029
Thailand	0.000389188	0.000128507	0.001072361	0.000388551	0.000128195	0.001069759
Togo	0.000234521	0.000100768	0.000841026	0.000235004	0.000100795	0.00084125
Tokelau						
Tonga	0.000586205	0.000237101	0.001977585			
Trinidad and Tobago	0.000711471	0.000205645	0.001715413	0.000715895	0.000206422	0.001721854
Tunisia	0.000137369	1.2518E-05	0.000104494	0.000308847	5.29151E-05	0.000441481
Turkey	0.000313445	8.93005E-05	0.000745134	0.000312998	8.77127E-05	0.000731886
Turkmenistan	0.000110976	3.12112E-06	2.60821E-05	0.000143654	1.09436E-05	9.12842E-05
Turks and Caicos Islands	0.000394337	6.90062E-05	0.000576101			
Tuvalu	0.00066755	0.0002445	0.00204			
Uganda	0.000441507	0.000102963	0.000859027	0.000434287	0.00010088	0.00084164
Ukraine	0.00030378	0.000133084	0.001110274	0.00030414	0.000131943	0.00110075
United Arab Emirates	3.07212E-05	5.19459E-08	4.38635E-07	6.1827E-05	6.78773E-08	6.16255E-07
United Kingdom	0.000321073	0.000210098	0.001752747	0.000345837	0.000205325	0.001712968
United States	0.000235919	0.000118247	0.000986593	0.000249016	9.94405E-05	0.000829738
United States Minor Outlying Islands	0.00045818	0.00015472	0.00129			
Uruguay	0.00045576	0.00017671	0.001473729	0.000448621	0.000176587	0.001472753
Uzbekistan	0.000150571	1.24277E-05	0.000103724	0.000206657	3.29732E-05	0.000275193
Vanuatu	0.000726171	0.000237481	0.001981256			
Vatican City	0.0004259	0.0001406	0.00117	0.0004259	0.0001406	0.00117
Venezuela	0.000465051	0.000159795	0.00133317	0.00043449	0.000139396	0.001162952
Vietnam	0.000511761	0.000168802	0.001408173	0.000512064	0.000168855	0.001408609
Virgin Islands, U.S.	0.000537998	0.000150991	0.001259588			
Wallis and Futuna	0.000596506	0.0002445	0.00204			
Western Sahara	4.52425E-05	0	0			
Yemen	5.16954E-05	3.56127E-07	3.02874E-06	0.000131805	2.57019E-06	2.16232E-05
Zambia	0.000268024	8.53383E-05	0.000712165	0.000268882	8.61578E-05	0.000719003
Zimbabwe	0.000181222	4.32041E-05	0.000360535	0.00018079	4.22441E-05	0.000352505

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