# From Wasteland To Oasis: Transformative Effects of Sustainable Agricultural Development



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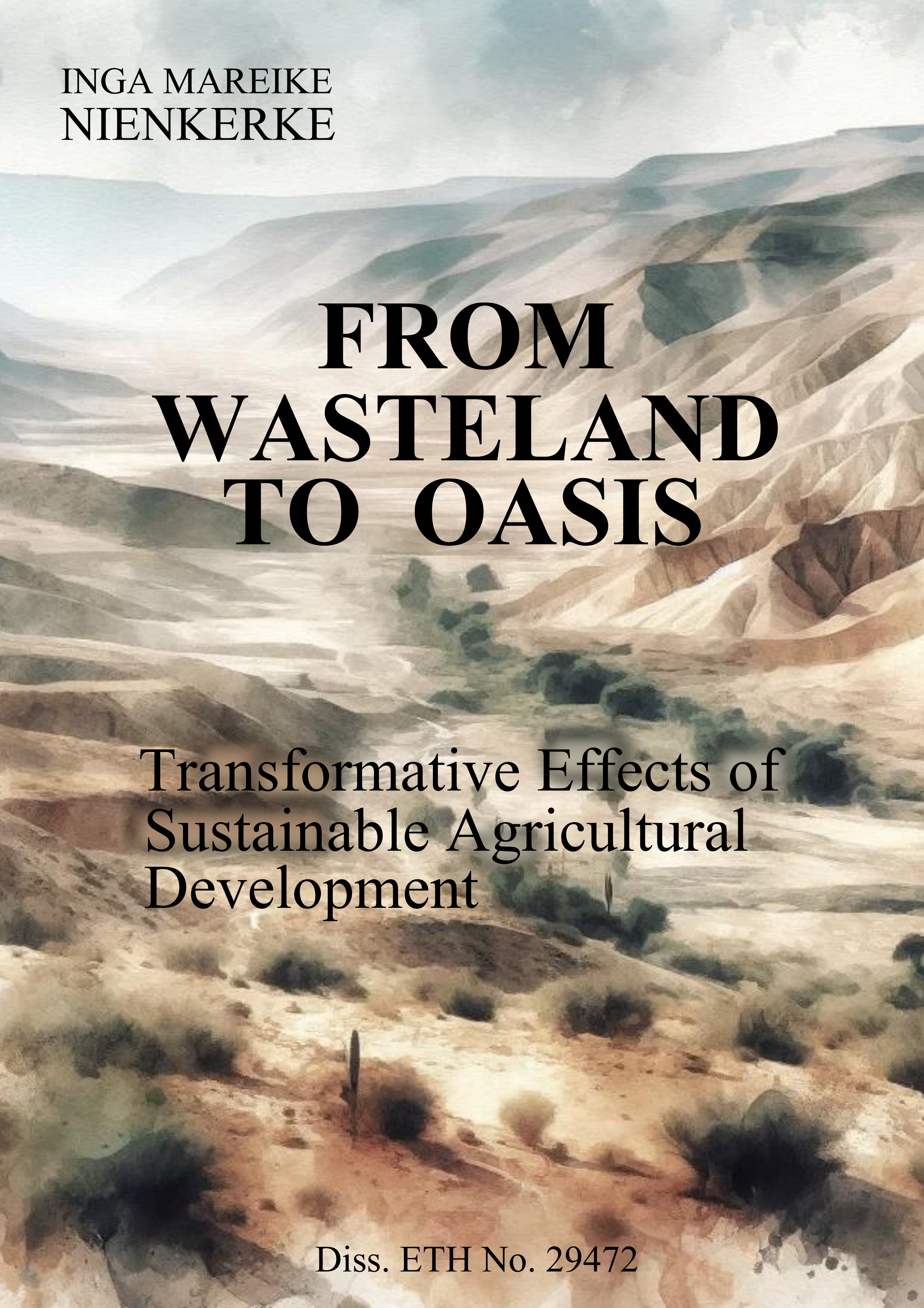

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## Transformative Effects of Sustainable Agricultural Development

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# FROM WASTELAND TO OASIS

## Transformative Effects of Sustainable Agricultural Development

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**ABSTRACT** 2

**ZUSAMMENFASSUNG** 4

**1 INTRODUCTION** 6

**1.1 Motivation and General Background** 6

**1.2 Box: “This Is Never Going to Work”—A Personal Anecdote** 12

**2 RESEARCH APPROACH** 13

**2.1 Research Questions** 13

**2.2 Study Context and Implications for Methodology** 14
*2.2.1 Adivasis* 14
*2.2.2 Sustainable Intensification Through the Wadi Concept* 15

**2.3 Research Design** 16
*2.3.1 Mixed Methods* 16
*2.3.2 Counterfactual Group* 16
*2.3.3 Natural Experiment* 17
*2.3.4 Sampling* 17
*2.3.5 Questionnaire* 18

**2.4 Research in Rural India** 18
*2.4.1 Measuring Income* 18
*2.4.2 Remoteness* 19
*2.4.3 Concepts of Time* 20
*2.4.4 Trust Building* 20
*2.4.5 Box: Breaking the Ice—A Personal Anecdote* 21

**2.5 Synopsis, Contribution 1** 21

**2.6 Synopsis, Contribution 2** 23

**2.7 Synopsis, Contribution 3** 25

**3 DISCUSSION** 28

**4 CONTRIBUTION 1** 31

**5 CONTRIBUTION 2** 54

**6 CONTRIBUTION 3** 79

**REFERENCES** 101

**ACKNOWLEDGEMENTS** 112

**Abstract**

In light of the alarming trends in resource degradation and human vulnerability, innovative strategies are urgently needed to increase the resilience of smallholder farmers. However, there is a limited evidence base to inform the development of effective policies. In response to this challenge, we examine the "Wadi" model, which fosters sustainable agricultural intensification, including fruit tree cultivation, water resource development, soil conservation, and intercropping. Our goal is to determine whether this approach can transform the so-called wastelands into valuable assets and thereby lift marginalized smallholders out of chronic poverty.

The program's geographic rollout facilitates a natural experiment, allowing an evaluation design with treatment and control groups. In this study, I follow a mixed-methods approach, including a survey of 2,000 households, randomly sampled from 188,231 participants across four Indian states, covering diverse geographic areas. I compare the program's household participants with the non-participants and run a linear regression analysis, ceteris paribus, comparing farmers who established integrated farming systems at different points in time. For the first time, impacts of such farming systems are analyzed on a large scale and after up to 23 years since establishment. I find significant improvements in socioeconomic factors, such as higher incomes, diversified income sources, positive life changes, higher life satisfaction, and better prospects for children. Additionally, I find environmental benefits associated with the program.

Moreover, I assess the program's potential to reduce the dependency on seasonal migration, a deeply entrenched but burdensome coping strategy for the rural poor who face seasonal livelihood insecurity, trapping many in a vicious cycle of chronic poverty, seasonal migration, and debt. A significant reduction in the intensity and frequency of seasonal migration can be reached, with spillover effects benefiting entire villages. My analysis of the challenges and migration patterns of seasonal migrants indicates that altering the underlying reasons for seasonal migration is crucial to enable the transition from distress to selective migration.

My results show that degraded farmlands can be converted into green assets when poverty alleviation and environmental regeneration are addressed holistically. The Wadi program's effectiveness in promoting sustainable development pathways suggests that scaling up the

program could yield substantial benefits in other regions as well. In this regard, I synthesize key lessons for success. The study's results and conclusions drawn from them contribute evidence that is valuable to the science–policy dialogue on rural development programs.

**Zusammenfassung**

Angesichts alarmierender Trends bei der Zerstörung natürlicher Ressourcen und einhergehender Vulnerabilität benachteiligter Bevölkerungsgruppen, sind innovative Strategien dringend erforderlich. Es gibt jedoch nur eine begrenzte Evidenzbasis für die Entwicklung wirksamer Projekte. Im Hinblick auf diese Herausforderung untersuchen wir ein Entwicklungsprogramm, das "Wadi Progamm", das die nachhaltige Intensivierung der Landwirtschaft fördert, einschließlich des Anbaus von Obstbäumen, der Entwicklung von Wasserressourcen, von Bodenschutzmaßnahmen und Intercropping. Unser Ziel ist es, festzustellen, ob dieser Ansatz so genannte Wastelands transformieren und hierdurch marginalisierte Kleinbauern aus chronischer Armut befreien kann.

Die geografisch-sukzessive Ausbreitung des Programms ermöglicht ein natürliches Experiment, das ein Evaluierungsdesign mit Treatment- und Kontrollgruppen erlaubt. Wir verfolgen einen Mixed-Methods Ansatz, einschließlich einer Umfrage von 2000 Haushalten, die nach dem Zufallsprinzip aus 188.231 Teilnehmern in vier indischen Bundesstaaten gezogen wurden und verschiedene geografische Gebiete abdecken. Zum ersten Mal werden die Auswirkungen solcher Anbausysteme in großem Maßstab und nach bis zu 23 Jahren analysiert. Wir vergleichen die Haushalte, die an dem Programm teilgenommen haben, mit denjenigen, die nicht teilgenommen haben, und führen eine lineare Regressionsanalyse durch, bei der die Landwirte, die zu verschiedenen Zeitpunkten integrierte Anbausysteme eingeführt haben, ceteris paribus verglichen werden. Wir finden signifikante Verbesserungen bei verschiedenen sozioökonomischen Faktoren fest, wie z. B. höhere Einkommen, diversifizierte Einkommensquellen, positive Lebensveränderungen, höhere Zufriedenheit und bessere Zukunftschancen für Kinder. Darüber hinaus stellen wir positive Wirkungen auf die Umwelt fest.

Außerdem untersucht die Studie das Potenzial des Programms, die Abhängigkeit von saisonaler Migration zu reduzieren, eine tief verwurzelte, aber meist auf Ausbeutung basierte Bewältigungsstrategie der armen Landbevölkerung, die mit saisonaler Existenzunsicherheit konfrontiert ist und viele in einem Teufelskreis aus chronischer Armut, saisonaler Migration und Schulden gefangen hält. Die Intensität und Häufigkeit der saisonalen Migration kann deutlich reduziert werden, und es werden Spillover-Effekte erzielt, von denen ganze Dörfer profitieren. Unsere Analyse der Herausforderungen und Jahreskreisläufe saisonaler Migranten

veranschaulicht, dass eine Änderung der Beweggründe für saisonale Migration entscheidend ist, um einen Übergang von notgedrungener zu selektiver Migration zu ermöglichen.

Die Ergebnisse demonstrieren, dass degradiertes Ackerland in grüne Wertanlagen umgewandelt werden kann, wenn Armutsbekämpfung und Umweltzerstörung ganzheitlich angegangen werden. Die Wirksamkeit des Programms bei der Förderung nachhaltiger Entwicklung legt nahe, dass eine Ausweitung des Programms auch in anderen Regionen erhebliche Vorteile bringen könnte. Hierzu zeigen wir ausschlaggebende Erfolgsfaktoren auf. Dies leistet einen wertvollen Beitrag zum wissenschaftlich-politischen Dialog über Möglichkeiten der ländlichen Entwicklung.

# 1 Introduction

This cumulative thesis comprises three scientific research contributions. These contributions investigate the manifold impacts of sustainable intensification under an agricultural development program, how it tackles the resource degradation and poverty nexus, the key factors leading to its success, and its potential to transform lives and places of chronic poverty and distress seasonal migration. An interdisciplinary approach is applied in the research. The focus of the first paper is on economic impacts. The second paper analyzes transformations of the socioeconomic phenomenon of seasonal migration. The third paper untangles how holistic outcomes can be achieved, including ecological benefits.

In the remainder of this chapter, I provide a detailed background (more than what is possible in journal formats) on the study context and its implications for the methodology, the research design, and the challenges of research in remote areas, followed by a brief synopsis of the findings and a discussion. Chapters 4–6 include the three contributions.

## 1.1 Motivation and General Background

Addressing environmental degradation is an important step in reducing poverty and promoting sustainable development. Over three billion people rely directly on land and soil, which are progressively deteriorating natural resources (FAO, 2017; IFAD, 2015; World Bank, 2018). Globally, a significant portion of natural resources (one-third of all lands and 20% of forest cover) has already experienced severe degradation (UNCCD, 2017). The natural resources that are highly degraded and the people, who are highly vulnerable, are interconnected by the so-called "natural resource degradation and human vulnerability nexus.". This concept has emerged from the interdisciplinary study of social-ecological systems and sustainable development and has gained momentum from the growing awareness of climate change, biodiversity loss, and resource depletion. It highlights a reciprocal relation, where deterioration of natural resources can exacerbate social and economic vulnerabilities and vice versa.

Two theories are closely related to the natural resource degradation and human vulnerability nexus and relevant to the background of this study, namely the environmental poverty trap and the livelihood framework. Both emphasize the interplay between socioeconomic factors and environmental conditions in shaping human well-being and resilience. On one hand, the environmental poverty trap posits that environmental degradation can lead to a vicious cycle of poverty and environmental degradation (Dasgupta & Maler, 1995). According to this model, poverty can lead to environmental degradation as individuals and communities resort to unsustainable practices, such as over-exploitation of natural resources, deforestation, and overgrazing, in order to meet their basic needs (Baland & Platteau, 1996). In turn, this environmental degradation exacerbates existing socioeconomic vulnerabilities by reducing the availability of resources and making it increasingly difficult for individuals and communities to escape poverty (Barrett & Swallow, 2006). The history of the concept can be traced back to the mid-20th century, when scholars began to recognize that poverty was not simply a lack of income but a complex and dynamic phenomenon (Sen, 1981). On the other hand, the livelihood framework emerged as a response to the limitations of traditional development approaches that focused solely on economic growth and ignored the diverse strategies and experiences of people living in poverty (Chambers & Conway, 1992). Scholars, such as Amartya Sen (1981) and Robert Chambers, challenged this narrow focus on economic growth and argued for a more people-centered approach. The livelihood framework is based on the idea that people's livelihoods are multidimensional and context-specific, shaped by social, economic, political, and environmental factors. The approach also emphasizes the importance of considering multiple dimensions of well-being, including human, social, natural, physical, and financial capitals (Scoones, 1998). Combining insights from both concepts sheds light into the mechanisms through which households can become trapped in poverty and into the strategies they employ to improve their situations.

Climate change further exacerbates the adverse effects of the relation between resource degradation and poverty by intensifying the detrimental impacts of environmental degradation and increasing the vulnerability of communities that are already struggling with poverty. The existing inequalities and poverty traps are reinforced, making it even more difficult for these communities to escape poverty. Authors of the IPCC (2019) expect climate change to worsen land degradation and food insecurity with high confidence. It will exacerbate the vulnerability-related risks of resource-dependent communities, further strain their adaptive capacity, and increase their susceptibility and exposure to climate shocks (Lange et al., 2018; World Bank, 2010). The combined forces of resource degradation and climate change could force more than 100 million people into poverty by 2030, especially in Africa and South Asia (World Bank, 2016), severely threatening food security (Scholes et al., 2018). Recently, all of these unfolding negative developments have led to an alarming reversal of poverty alleviation (World Bank, 2020).

Since three billion people, roughly 75% of the world's poor, live in rural areas and the major portion of their incomes is derived from agricultural activities (World Bank, 2018, 2020), there is an urgent need for land use policies to build the resilience of smallholder farmers. Smallholder farmers are defined as those who cultivate small plots of land, typically less than 2 ha. They are particularly vulnerable to extreme poverty because they often rely on subsistence agriculture, which means that their livelihoods depend on the production of food for their own consumption, with any surplus sold in local markets. Conventional extension and agricultural support services often fall short in addressing farmers' needs, restricting their ability to obtain enhanced production inputs and technologies (Singh et al., 2020).

The question of how smallholder farmers' livelihoods can be improved is subject to debate. Do agricultural development programs constitute a sustainable way forward? Numerous initiatives have been launched to combat rural poverty but with frequently disappointing outcomes (Ademola et al., 2018; Bhaumik, 2008; Bjornlund et al., 2020; Pittock et al., 2020; Roumasset, 2007; Wiggins, 2014). This has resulted in increasing dissatisfaction with the effectiveness of many agricultural projects and programs (Roumasset, 2004). Around the world, there are some famous examples of agricultural development projects that faced challenges and controversies. The Narmada Valley Development Project in India aimed to construct dams for irrigation, drinking water, and hydroelectric power but led to displacements and conflicts (Baviskar, 1999). The Mahaweli Development Programme in Sri Lanka sought to develop reservoirs and irrigation systems but struggled with infrastructure maintenance and environmental impacts (Paranage, 2019). The Groundnut Scheme in Tanzania intended to cultivate groundnuts but faced infrastructure and climatic challenges, ultimately resulting in financial losses (Esselborn, 2013). The Sao Francisco River Irrigation Project in Brazil targeted the development of large-scale irrigation systems but faced cost overruns, delays, and insufficient community involvement (Lee et al., 2014). The Biofuel Projects in Indonesia and Malaysia aimed to boost economic growth through oil palm cultivation but led to deforestation, biodiversity loss, and community conflicts (Mohan et al., 2021; Obidzinski et al., 2012; Papilo et al., 2022). Likewise, the Green Revolution in Africa is not known for its success stories (Holt-Gimenez et al., 2006; Wise, 2020).

Greening efforts worldwide have shown that local poverty can be both increased or decreased by these projects. While some households may benefit, others may be negatively affected (Coleman et al., 2021; Ramprasad et al., 2020). The World Bank found that its own natural resource management projects struggled to balance resource recovery with the welfare needs of vulnerable resource users (Independent Evaluation Group, 2021). Turner (2021) observed that the Great Green Wall initiative paid little attention to the needs of the most vulnerable populations. Similarly, in China, controversies arose regarding the treatment of indigenous people in afforestation projects (Rozelle et al., 2000). In India, the exclusion of people by Joint Forest Management initiatives and afforestation drives was recognized as a major drawback, leading to conflicts that had harmful impacts on large numbers of tribal and forest-dwelling communities (Bhattacharya et al., 2010).

Certainly, it is challenging to achieve smallholder resilience, and there are many pitfalls and no one-fits-all solution, especially in the complex context of the resource degradation and poverty nexus. The attractive vision that resource recovery practices will inherently result in enhanced social resilience is not entirely accurate. In numerous instances, afforestation projects or green initiatives might even worsen the vulnerability of resource users (Coleman et al., 2021; Ramprasad et al., 2020; Rozelle et al., 2000). For example, the World Bank admitted that it had not adequately addressed the resource-related vulnerability of resource-dependent people in its projects that applied natural resource management practices (Independent Evaluation Group, 2021). Additionally, risks in global mitigation policies and adverse tradeoffs with food security are frequently overlooked (Doelman et al., 2020). As highlighted by Oxfam (2021), afforestation and new forest planting, two prevalent offset measures, pose significant threats to food security. Nature-based solutions that emphasize agroforestry—integrating crop cultivation or grazing with tree farming—are more effective. These approaches enable land use for food production while capturing carbon.

The evolution of agroforestry and more broadly integrated farming systems can be traced back to ancient civilizations, where farmers practiced mixed cropping and integrated tree–livestock systems to maintain soil fertility and enhance productivity (Sinclair, 1999). In recent decades, the scientific understanding of these systems has deepened, leading to the development of more advanced and site-specific integrated systems and agroforestry practices. Modern research has focused on optimizing the integration of different components, selecting appropriate species, and improving management practices to enhance the ecological, economic, and social benefits of these systems (Mbow et al., 2014). These systems have now been recognized as sustainable and ecologically sound approaches to agriculture, with significant potentials for addressing current environmental and socioeconomic challenges (Garrity, 2004; Jose, 2009; Lovell et al., 2018; Nair, 2012).

Nonetheless, there is limited evidence of these programs' sustained success in tackling rural poverty (de Janvry & Sadoulet, 2012). This issue makes rural development challenging; besides the persistent nature of chronic poverty and often harsh environmental conditions, there is a lack of evidence of successful agricultural development programs to inform the design of future programs (Dercon, 2009; Dorward, 2013). Agricultural development has been a cornerstone of human civilization, with its roots going back to the Neolithic Revolution (Diamond, 1997). However, in their survey of the past century's literature on agricultural development, Barrett et al. (2010) concluded that knowledge about how to foster rural development remained incomplete, limiting stakeholders' ability to pursue it. While some agricultural development programs have shown short-term positive impacts, many have been unable to achieve long-term, sustainable results. With the scarcity of long-term success stories, coupled with enduring doubts surrounding the support and financing of rural agricultural projects, there is a pressing need for evidence of potential success. Although the past decade witnessed a shift toward evidence-based policy and a greater focus on learning from evaluations (Maredia, 2009), existing literature offers limited systematic guidance for agricultural policymakers. Development banks' standard project evaluations primarily consist of brief field visits and rapid rural appraisals, which cannot be compared with scientific analyses grounded in quantitative data. Despite the expenditure of billions of dollars, there is comparatively little knowledge about the net impact of the majority of programs (Center for Global Development [CGD], 2006). While the Sustainable Development Goals (SDGs) call on the international community to invest in doubling the agricultural incomes of small-scale food producers, and current yield trends indicate the need for groundbreaking innovations in the world's rainfed regions to achieve the SDGs, there is scarce rigorous evidence to guide the investments required to meet these goals (DIME, 2021).

Over 50% of India's workforce is directly employed by the agricultural sector, and small and marginal farmers with landholdings under 2 ha account for 82% of all agricultural labor. This demonstrates significant land fragmentation and limited economies of scale (FAO, 2022). Additionally, the relation between resource degradation and poverty is particularly pronounced, leading to seasonal livelihood insecurity, thus trapping many farmers in a vicious cycle of chronic poverty and seasonal migration. Many smallholders grow a few food crops, such as rice, millets, and pulses, mostly without any inputs and technologies and yielding barely enough output to meet their families' needs (Wani et al., 2009). As the modest yields from rainfed subsistence agriculture are insufficient to secure their livelihoods, these farmers and their families engage in seasonal migration for 6–8 months annually, often under exploitative circumstances (Ellis, 2003). While several economic theories view seasonal migration as a useful coping mechanism or a rational investment choice, particularly when the overall anticipated benefits surpass the associated costs (Stark & Bloom, 1985; Taylor, 1999), in this case, seasonal migration is a deeply entrenched but burdensome coping mechanism for those who cannot sustain their lives at home throughout the whole year; it is mostly for survival rather than for well-being or profit and exacerbates the poverty trap (De Haan, 1999). On reaching their destinations, many migrants live in open spaces or temporary shelters in unhealthy environments, lacking access to safe drinking water, sanitation, electricity, or food that they can afford. Oppressive structures are perpetuated through labor-contracting arrangements, potentially even more exploitative than the officially prohibited caste-based oppression (Mosse et al., 2002; Olsen & Ramanamurthy, 2000). Seasonal migrants typically work on construction sites, cotton and sugarcane farms, saltpans, stone quarries, or brick-making kilns—jobs known for low wages and harsh work conditions.

Several factors contribute to this seemingly hopeless situation (Lambin et al., 2001). The marginalized smallholders' farmlands can be categorized as highly degraded crop lands, with very little topsoil and organic carbon. Deforestation and widespread use of shifting agriculture significantly contribute to soil erosion, since the absence of vegetation allows fertile topsoil to be swept away during heavy rainfalls (Lal, 2001). This process decreases the ability of water to infiltrate the soil and replenish underground reservoirs, resulting in water shortages (Brauman et al., 2013; Rockström et al., 2009). Consequently, the affected land is transformed into what is commonly referred to as 'wasteland.' This, combined with scarce capital, limited alternative job prospects, debt, financial inexperience, insufficient understanding of advanced farming techniques, inadequate diversification, and low educational attainment, cements the low level of development that persists across generations (Asadullah & Yalonetzky, 2012; Mehta & Shah, 2003). This ongoing problem occurs despite the Government of India's assertive affirmative action policies and significant income improvements among the broader Indian population (Thorat et al., 2017).

## 1.2 Box: "This Is Never Going to Work"—A Personal Anecdote

A personal anecdote: I was working in the evaluation unit of the German Development Bank (KfW), where projects are evaluated years after project support has ended, to assess whether the projects were successful. The evaluations of German development cooperation (and those of other development banks) usually apply a case study approach, based on rapid rural appraisal and existing data and information, leading to an expert judgment on a project's development success, according to the OECD Development Assistance Committee's (DAC) criteria of relevance, effectiveness, efficiency, impact, and sustainability. A new list of projects had been prepared for the next round of evaluations, and one that aroused my interest was the Adivasi Development Program Gujarat (ADPG). It was a project in the green sector, whose specific target group comprised the tribal communities in the state of Gujarat, India. I had just conducted research on irrigation projects, realizing that agricultural projects were often not among the successful ones. Therefore, frankly speaking, a project with the goal of lifting farmers in degraded areas out of poverty sounded bold. My boss, an experienced project manager with a solid background in agricultural economics, prophesied, "This is never going to work. How should some trees on one acre lift people out of poverty?" We traveled to India and witnessed what we had not expected. It was the dry season, and the orchards stood out as green patches in an otherwise barren landscape; the farmers whom we visited were proud of their trees and incomes and grateful for the project. I insisted on visiting a village outside the project area as well—the place was dusty, without any green vegetation and seemed almost abandoned, since most of its inhabitants were abroad on seasonal migration. We had a focus group discussion with the remaining villagers and learned about their lives in misery. At NABARD, the Indian Development Bank (National Bank for Agriculture and Rural Development), a senior official told me that the project's implementing agency (an NGO) always reported that the project was successful, which was not surprising, as the NGO needed funding. She said that what they (the policymakers) really needed was an independent scientific assessment as policy advice. This encouraged me even more to set up a research project in order to investigate the circumstances of rural livelihoods and the program's impact in depth.

My motivation for the research in this thesis is the practical problem of finding a development pathway for people living in extreme poverty. Toward this end, I seek to contribute knowledge and evidence to the policy discourse on development programs. I identify research questions for which previous work has provided suggestions but no clear answers and for which the research context in India has the potential to provide new insights. The results contribute to our fundamental understanding of sustainable intensification in the context of extreme poverty and resource degradation, as well as which policies may provide relief and resilience.

# 2 Research Approach

In Chapters 4–6, I lay out in detail the specific methodologies for each of the studies and the reasons for choosing these approaches. Here, I present some general comments on how the combination of research questions and the characteristics of the Indian rural context influenced the general methodological approach applied in these studies. I also offer insights into the main challenges.

## 2.1 Research Questions

The overall goal of this research project is to understand the livelihoods of marginalized smallholders, especially in the context of the resource degradation and vulnerability nexus, whether there are ways to promote sustainable development, and specifically if and how the Wadi program can provide such a development pathway. In this multifaceted context and interdisciplinary undertaking, three core topics have emerged: economic aspects (of development), the phenomenon of seasonal migration, as well as the program's holistic approach and impacts. A scientific paper is dedicated to each topic, tackling the following research questions:

1. For impoverished small-scale farmers, income plays a crucial role in their well-being, as it enables them to provide for various pressing necessities, including food, housing, and education. Can sustainable agricultural intensification enable marginalized, smallholder farmers to break out of chronic poverty? Can it improve the livelihoods of chronically poor smallholders?

2. Seasonal migration is a deeply entrenched but burdensome coping strategy among the rural poor who face seasonal livelihood insecurity, trapping many in a vicious cycle of chronic poverty and seasonal migration. Can rural agricultural development programs effectively transform these livelihoods and places of seasonal migration? We consider three questions in sequence. First, what are the general challenges and migration patterns of seasonal migrants, including the

factors that play a role in their decision to seasonally migrate? Second, can a rural agricultural development program—in this case, the Wadi program— reduce seasonal migration? Third and finally, are there possible spillover effects?

3. We assess the program's holistic approach and the potential of fruit trees in the context of the environmental resource degradation and vulnerability nexus. Can fruit trees transform wastelands into valuable assets and lift marginalized smallholders out of poverty?

## 2.2 Study Context and Implications for Methodology

### *2.2.1 Adivasis*

In India, typically the most affected people are the members of native tribal communities (Adivasis), who frequently experience geographical and social isolation from the broader Indian population. According to the German linguist and cultural scientist Harald Haarmann (2016), the Adivasis migrated to South Asia from the west even before the Dravidians and Indo-Aryans. They lived by hunting and fishing and still constituted the majority of the subcontinent's population in the 4th millennium BC. Later, they resorted partly to agriculture, but over time, they lost an increasing amount of their ancestral lands to the surrounding majority population, which pushed them into inhospitable areas (Haarmann, 2016). This displacement and loss of land have had a significant detrimental impact on their livelihoods and has reduced their access to resources, such as fertile soil, food, water, and fuel. Currently, most of the families own just 0.5–1 ha of land, which is used for subsistence farming. Despite being an integral part of the country's cultural and social fabric, Adivasis face widespread discrimination and exclusion, including limited access to education, healthcare, and employment. This discrimination is perpetuated by a combination of factors, including the lack of recognition of their rights, the absence of legal protection, and deeply ingrained social and cultural biases and prejudices. In theory, Adivasis have the same rights, such as access to a bank account or a school. In focus group discussions, we learned that in reality, many do not make use of this opportunity because they face discrimination at a bank or in school. Throughout the years, the Adivasis/Scheduled Tribes have been treated as second-class citizens—if citizens at all. They have been deprived of the forests and resources on which they traditionally depended; their lands were turned into legal properties of British-designated landlords and exploited. The Adivasis were forced to pay taxes, and if unable to do so (which was often the case), they were coerced to become bonded laborers. To improve the living situation of the Adivasis, the Indian government has enacted protective laws, on one hand, and implemented numerous specific programs and projects, on the other hand. However, neither the laws—such as the ban on the transfer of Adivasi land to non-Adivasis, land reforms, the ban on bonded labor—nor the programs and projects for infrastructure development, health promotion, and poverty alleviation were able to sustainably improve the Adivasis' situation because they remained incomplete, were hardly implemented, or failed to address the reality of life of the Adivasis.

### *2.2.2 Sustainable Intensification Through the Wadi Concept*

Traditionally, the Adivasi communities lived off the forest through hunting, gathering, and engaging in primitive agriculture. Today, they survive on a combination of subsistence farming and seasonal migration. Nevertheless, their degraded land constitutes an important resource. For the majority of households, small parcels of degraded land provide the only means of food for their subsistence for part of the year. Despite governmental and non-governmental initiatives to find solutions, they face a vicious cycle of chronic poverty, low productivity, seasonal migration, and indebtedness/debt. Against this background, the Indian NGO BAIF (BAIF Development Research Foundation, formerly registered as the Bharatiya Agro Industries Foundation) initiated the Wadi approach in the early 1980s in Valsad and the Dangs districts in the state of Gujarat. "Wadi" means "small orchard" in Gujarati. Talks with the tribal communities revealed that most households owned about 1 acre of hilly, low productive land and that they felt connected to trees and forests. The idea arose to help the Adivasis by converting their own wastelands into plantations of fruit, forest trees, and intercropping. This was made possible with soil conservation and water development measures. Around this core activity, a number of other activities were gradually added, such as improved agricultural techniques, the introduction of vegetable cultivation, kitchen gardening, or farm waste recycling to produce organic fertilizer. Through this holistic approach, sustainable intensification of the wastelands was envisaged to provide food security and cash incomes and to eventually render seasonal migration obsolete. After years of experimentation, the Wadi model was crystallized and introduced as a comprehensive program that expanded with funding from KfW. The program has several stakeholders: KfW as the donor agency, NABARD as the national-level organization through which funds are channeled, BAIF-DHRUVA as the implementing agency, as well as the participants. Various village-level, community-based organizations and local institutions, such as Gram Vikash Mandals (GVMs), Ayojan Samitis, and Self-Help Groups (SHGs), are also significant stakeholders, contributing to the program. It has been replicated in 9 states, covering 188,700 families under BAIF.

## 2.3 Research Design

### *2.3.1 Mixed Methods*

We followed a mixed methods approach, combining qualitative and quantitative methods to help generate hypotheses and formulate research questions before collecting quantitative data. Our qualitative methods did not rely on predetermined responses but included focus groups, interviews with selected participants, non-participants, and other key informants, as well as participatory research. Although the qualitative observations were not statistically representative of the participants and therefore not generalizable, they were extremely valuable in gaining a deeper understanding of the livelihoods in general and the impacts of the program in particular in order to formulate research questions and to fine-tune the questionnaire. Following Creswell's (2014) definition, we took an exploratory sequential approach, where we used qualitative findings to develop hypotheses and to clarify the research questions that needed to be addressed in the quantitative data gathering. We then applied an explanatory sequential approach, where the qualitative data provided the context and explanations for the quantitative results and an understanding of the outliers.

### *2.3.2 Counterfactual Group*

The main research task was to rigorously analyze the program's impacts. Herein lies the difficulty to establish the causality of the program and observed outcomes and to rule out any influences other than the program that explained the outcomes. What is the causal impact ($\Delta$) of a program (P) on an outcome (Y)?

The following basic formula explains this:

$$\Delta = (Y|P = 1) - (Y|P = 0)$$

The causal impact ($\Delta$) of a program (P) on an outcome (Y) is the difference between the outcome (Y) with the program and the same outcome without the program.

To find out what would have been the outcome for a program participant in the absence of the program, the crucial task was to construct a comparison group. This would need to be as similar as possible to the treatment group because this would influence the internal validity and assessment of the causal impact. “A valid comparison group (1) has the same characteristics, on average, as the treatment group in the absence of the program; (2) remains unaffected by the program; and (3) would react to the program in the same way as the treatment group, if given the program” (Gertler, 2016, p. 52). Furthermore, a major objective was to ensure that the estimated impact would be free of selection bias. Selection bias occurs when unobserved reasons for program participation are correlated with outcomes.

### *2.3.3 Natural Experiment*

We were fortunate that the program’s operational rules for selecting participants constituted the opportunity for a natural experiment. Due to resource constraints, logistical and administrative limitations, and excess demand, the program was being phased in over time, meaning that it began in one district and was then rolled out. This made it possible to take villages outside the program area as comparison groups because they were eligible but not incorporated at that time, as well as a control group of “recent participants” who lived in the villages that were just incorporated into the program but did not receive any benefits yet. The long history of the program also made it possible to compare farmers, ceteris paribus, who established Wadis at different points in time, as well as to perceive program participation as a development pathway.

### *2.3.4 Sampling*

I chose to limit the population of interest to the four states of Gujarat, Maharashtra, Rajasthan, and Karnataka because in these states, we would find thousands of Wadis that were established at different points in time, reaching as far back as 1995, up to recent participants, who just signed up for the program. I used random sampling to ensure external validity—that is, the sample accurately represented the population; therefore, the results could be generalized to the population. With the complete lists of participants from the project implementation, I had an ideal sampling frame at hand. Most were digital Excel files and thus easily randomly sampled. However, some lists from the earlier years were not digitalized but stored in rusty lockers in old field offices. Special efforts were needed to collect these and to take a random sample. In those cases, we wrote numbers in front of the names, randomly sampled the numbers, and then added the respective names to the sample.

### *2.3.5 Questionnaire*

Four different Indian states meant translating the questionnaire into four different languages and scripts. It was an iterative process of developing, field testing, and translating the questions for the survey. The survey was conducted in remote areas. Clearly, it would be impossible to visit all 2,000 households several times; therefore, the goal was to gather enough data to cover the hypotheses on several topics and the indicators for all impacts in one interview that should not last much longer than 1 hour. This was achievable by using the ODK software, to be used on the interviewers' smartphones, and programming the questionnaire in Excel with skip patterns and conditionalities, so that no time would be wasted with questions that were irrelevant to a specific case. For example, only households with school-aged children were asked questions on the children's education; only people who reported seasonally migrating were asked questions on seasonal migration. Two training sessions for interviewers were conducted in Pune, Maharashtra, with the teams from all states, and required a lot of translation as well to ensure that the information and exercises were understood by all.

## 2.4 Research in Rural India

### *2.4.1 Measuring Income*

One main aspiration of the research project was to analyze how the Wadi program would affect the livelihoods of poor smallholders. While some effects were visible at first sight, cutting to the core and being able to statistically analyze trends in income over time turned out to be a complicated undertaking. These families were extremely poor, even by Indian standards. Their incomes were so low or in the strict definition of a value on a payroll, even non-existent, that a few dollars more per day would mean doubling or tripling their available money. Therefore, any increase in their incomes would make a big difference in their livelihoods because with more money, many urgent needs could be fulfilled, such as food, medication, or other necessities. It was therefore clear that income would need to be measured.

How could income be measured when there was no income in the traditional sense (i.e., no salary or tax bill)? Three additional issues made data gathering in this case tricky: self-consumption, irregular payments, and multiple income sources. The fact that self-consumption should be taken into account is a well-known issue in subsistence farming. Otherwise, comparisons are not possible. Obviously, someone who owns some land to cultivate at least some food for one's family possesses some sort of asset and gains something, even if nothing is saved in a wallet or on a bank account. For example, one family grows enough to feed all its members but has no income at all; another family earns some money, but it is insufficient to buy enough food to feed everyone. When only asking about income, the second family would be rated as less poor than the first, even though its members go to bed hungry.

When we were visiting a cooperative, we witnessed the following scene: two children, about 4 and 7 years old, walked in and handed a small bag of unprocessed cashew nuts to the manager of the cooperative. He weighed the nuts and paid the little traders, who then proudly left as quickly as they came. These situations are typical; while farmers have to sell some produce, such as mangoes, directly after harvesting, some fruits are sold whenever they are ripe, and some non-perishable goods are sold whenever the farmers need money. Moreover, families typically have several income sources throughout the year, such as from various agricultural products and from several different occasions of seasonal labor.

With occasional earnings and with neither a paycheck at the end of the month nor a yearly tax report, it is difficult for anyone to know one's annual income. In the survey, we therefore asked people to list all income sources and all things they cultivated. We then asked for everything: first, how much was harvested and second, the price per kilogram, regardless of whether the produce was sold or self-consumed. We then multiplied the amount and the price per kilogram and added all other income sources, such as from seasonal migration, welfare schemes, or small businesses or other work.

### *2.4.2 Remoteness*

One main challenge was remoteness, which was, of course, fundamental/inherent/at the core of a research project on marginalized rural communities and therefore not possible to overcome. I wanted to conduct the research in four different Indian states in order to cover geographically and climatically varying regions. Furthermore (as described in detail in Contribution 2), seasonal migration is a widespread coping mechanism, which means that many people are not home for much of the year. The survey therefore had to be planned well, so the interviewers would arrive in the villages when there was a high probability to meet the members of the sampled households. The inevitable result of the research in these remote areas, under these circumstances, was that conducting the survey (including traveling to the sampled villages and visiting over 2,000 households) was cumbersome and time-consuming, at the same time yielding new exciting insights.

### *2.4.3 Concepts of Time*

Many well-established tools in academic research (whose participants are educated), such as Likert-type items with 9-point scales (e.g., ranging from "strongly agree" to "strongly disagree"), are problematic in marginalized rural areas where many participants have limited literacy and numeracy skills. For example, many parents did not know the years when their children were born or the latter's exact ages. Often, they also did not know the current year. This might be surprising from our western perspective, where date and time are fundamental for most activities. However, for many households in the research areas, these are rather random facts, which are simply unimportant in their day-to-day lives. They care about their next meal, about monsoons, and how to survive after a meager harvest until the next harvest—all things that are not written on a calendar. They might not know how far it is in kilometers to the next water source or school, but they know how long it takes to walk there. One should be aware that when asked, most people in those marginalized areas would state any date or year or number, rather than revealing or even realizing that the exact answer was unknown to them. Consequently, I tried to avoid the concept of specific years in the questionnaire. What matters in the yearly cycle are festivals and the seasons (*kharif*, etc.); it is therefore more useful to formulate questions around those concepts or to ask about "last year" or "last season" (instead of, e.g., "in the year 2019").

One solution for questions to be answered on a scale, which we tested extensively with out-of-sample participants, was to use 5 points, from good to bad, visualized by holding up one hand and showing 5 fingers, then selecting a finger between the best and the worst option.

### *2.4.4 Trust Building*

Even in recent history, hundreds of thousands of Adivasis have been forced off their lands due to infrastructure projects, such as highways or the Sardar-Sarovar Dam. It is therefore not surprising that they are at first skeptical of foreigners, particularly those groups of well-dressed, light-skinned men who arrive in these quiet and marginalized areas in large cars, whirling clouds of dust. At the beginning of the project, many potential beneficiaries were afraid that the developing program would be a coverup for a "secret" plan to plant trees on their lands and to then take the lands away. It was therefore crucial to gain the trust of the communities at the start of the implementation period of the development project, as well as for the research. One way was to include people from the communities as the so-called barefoot consultants in the implementation process. For the research, I also obtained the support of locals as guides, who spoke the local dialect. With their help, it was fairly easy to organize focus group discussions and to conduct interviews.

#### *2.4.5 Box: Breaking the Ice—A Personal Anecdote*

Another way was to approach villages by a vehicle similar to those used by the few locals who had vehicles at all—old motorbikes. Accompanied by my Indian research colleague, I decided to send our car driver on a break and to use a motorbike instead. The villages are basically traffic-free, and the roads are unpaved. When a white woman drives by on an old-fashioned motorbike (women usually never drive), curiosity is guaranteed. The ice is broken, and people are talkative, eager, and patient to share their experiences. Another simple but fascinating ice-breaker and surprise, especially for children, was a Polaroid camera. Most households have a few timeworn pictures, if at all, of themselves or their grown-up children, usually from their weddings. After we took a picture with the Polaroid camera, it felt like magic to the children when a white sheet came out of the plastic box and slowly developed into a photograph. They were excited about this little present, and we were thankful for their trust and time. The best way to really experience the rural livelihoods was staying with a family in a village. Observing and participating in the daily routine, sleeping and cooking on the mud floor, plowing the field with draft animals, or carrying headloads of fruits made us better understand the hardships and merits of village life and provided plenty of opportunities for spontaneous conversations and insights.

## 2.5 Synopsis, Contribution 1

There is an urgent need for land use policies to build resilience for smallholder farmers, particularly in rural areas where the majority of the world's poor reside. Despite numerous programs and efforts aimed at eradicating rural poverty, many have been disappointing, with some even worsening the situation for vulnerable populations. There is a significant knowledge gap in understanding the long-term success and impacts of these programs, limiting the ability to develop effective policies. This study aims to provide evidence of the Wadi program's impact and effectiveness, since no rigorous scientific study currently exists, despite anecdotal evidence suggesting its success. This can inform the science–policy dialogue and serve as a role model for future agricultural development programs. The Wadi program, which began in Gujarat in the 1990s, has expanded to various districts across India, involving nearly 200,000 families. The program's design focuses on supporting families in growing fruit trees on degraded lands while implementing soil and water conservation measures. Capacity building, cooperative community organizations, and initial financial support are also included as essential components of the program.

We used a mixed-method approach, beginning with qualitative evidence gathering, followed by quantitative evidence to identify significant findings, and ending with additional qualitative evidence to deepen the understanding of the processes involved. Based on the qualitative data, a quantitative survey was developed and conducted face-to-face in four Indian states. The survey covered socioeconomic indicators, farming, food security, seasonal migration, education, and well-being. Rigorous testing, translation, and interviewer training ensured the quality of the survey questions. The Wadi program's operational "rules" enabled us to choose a robust method and a counterfactual group. The program was implemented in a randomized rollout, gradually covering eligible beneficiaries in specific areas before moving to the next. This approach produced conditions comparable to a randomized evaluation design, providing good internal validity. Three control groups were used for comparison: recent participants, non-participants in Wadi villages, and households in control villages. The survey was conducted among 1,860 households, with 1,132 program participants and 728 non-participants. These households were randomly sampled from a population of all households that participated in the program across the four states.

We performed several analyses to establish the causal relations between program participation and its impacts. We compared the incomes and the numbers of income sources between the treatment group and the control group using t-tests and Wilcoxon rank-sum tests. We also analyzed income increases and income sources over time, taking advantage of the program's 23-year implementation period in different villages. This allowed comparisons among farmers who established their Wadis at different times, helping us to understand the trend as a development pathway. Additionally, multiple regression analysis was used to control for potentially confounding factors, examining incomes, income sources, positive life changes, life satisfaction, and perceived opportunities for children. Statistical analysis and field verification showed that the participants significantly increased their incomes, with average annual net incomes of INR 73,000 compared with INR 40,000 without the intervention. The program participants' average annual income was almost double that of the control groups. The participants had an average of 8 different income sources compared with around 6 for the control groups. Over time, the participants' incomes continued to increase, and they diversified their income sources. Many developed an entrepreneurial spirit and adopted improved farming techniques, enabling up to three harvests per year. Other significant factors included land size, education level, electricity availability, distance to secondary school, and distance to the nearest water source. The increased income resulted in an improved standard of living, improved food security and dietary diversity, positive life changes, increased life satisfaction, and better opportunities for the next generation.

The Wadi program enables marginalized smallholders to break the cycle of chronic poverty by converting wastelands into profitable assets. Various factors, such as landholdings, education, electricity, water availability, and others, have significant impacts on annual incomes and income sources. The program stimulates the local economy by providing jobs and promoting agri-business growth, while improving social benefits, such as self-confidence, women empowerment, and quality of life. The diversified income streams from the Wadi program act as a hedge against risk and provide stability for farmers. Key success factors include building good relationships with locals, participant involvement in management, extension services through local field guides, protective irrigation, and better market access through cooperatives. The study highlights the success of the Wadi model and suggests that it can be scaled up for other rainfed, arid agro-ecosystems. Further research is needed to identify the most successful Wadi composition and investigate other potential impacts, such as seasonal migration and groundwater levels. The Wadi model can provide a reliable livelihood source for the rural poor, helping them escape the cycle of chronic poverty, especially in the face of food and climate crises.

### 2.6 Synopsis, Contribution 2

In 2020, the plight of Indian seasonal migrants gained global attention when the COVID-19 lockdown left them stranded, forcing them to walk hundreds of kilometers back to their villages. Their sudden job loss and inhumane living conditions highlighted the long-neglected issue of seasonal migration and the struggles faced by many poor rural households in India. This contribution emphasizes the importance of addressing the root causes of seasonal migration and finding alternative coping strategies to break the cycle of chronic poverty and seasonal migration. In India, smallholder farmers often rely on seasonal migration as a coping strategy due to insufficient rainfed agriculture. This migration occurs under exploitative conditions and perpetuates chronic poverty, also referred to as intergenerational poverty. Estimates suggest that seasonal migration affects a significant portion of India's workforce and population, with the numbers expected to rise. Despite the importance of seasonal migrants to various sectors, they often lack protection and benefits from employers and the government. Ineffective policies and relief efforts often address the symptoms of seasonal migration rather than the underlying causes. To find a solution, it is necessary to strengthen livelihoods in rural areas, create employment opportunities, and increase agricultural productivity.

The Wadi program helps families cultivate fruit trees and intercrops by providing support for soil and water conservation, capacity building, and financial assistance during the initial gestation period of 3–5 years. The program's implementation allowed a natural experiment, as it was gradually phased in geographically since the early 1990s. This geographic rollout enabled a randomized evaluation design that minimized selection bias and ensured good internal validity. We used a mixed-method approach, including a survey in Rajasthan, Maharashtra, Gujarat, and Karnataka, conducted with 1,860 randomly sampled households, and collecting detailed information at both individual and household levels. We compared three groups: participants, non-participants in program villages, and households in control villages. We used stepwise linear regressions to analyze the data and draw conclusions.

The analysis addressed three questions: 1) understanding the challenges and migration patterns of seasonal migrants, 2) determining whether the Wadi program would reduce the intensity and frequency of seasonal migration, and 3) identifying possible spillover effects. We found similarities and differences among the three groups (participants, non-participants in program villages, and households in control villages). They were all similar in age range, remoteness, landholding, household size, and gender ratio. However, they had differences in wealth, debt, income sources, cultivated and irrigated land area, income from farming, and water availability. The treatment group reported more positive outcomes, such as having a kitchen garden, enough food to eat, and better education for family members under 18 years old. The treatment group also showed lower values for migration parameters (number of migrants, income from seasonal migration, intensity, farthest destination, longest duration, and frequency) and debt. All groups preferred farming over seasonal migration, which is not surprising since seasonal migrants face challenges, including poor health, food scarcity, and negative impacts on life satisfaction and their children's education. Examining only seasonal migrants across the three groups, we found that people from the treatment group who decided to migrate seasonally did this by choice, not for survival, and could "afford" selecting better job offers. We also investigated factors influencing seasonal migration and found that debt, remoteness, and household size increased seasonal migration, while factors such as farming income, area of irrigated land, number of fruit trees, and education levels reduced it. The program participants reported improvements in their lives, including increased incomes from their lands, better childcare, and enhanced dietary diversity. They experienced a significant reduction in the frequency and intensity of seasonal migration compared with the control group households. Over 60% of participating households reported having at least one person who used to migrate seasonally but subsequently stayed home since joining the program. Spillover effects were evident as non-participants in program villages also undertook less seasonal migration. Non-participants who initially did not join the Wadi program later recognized its benefits and established Wadis at their own expense. Wadi owners mentioned the trees' resilience to unseasonal rainfalls (which damaged rice and wheat crops) as an additional advantage.

We conclude that a rural development program can help marginalized, smallholder farmers in India break away from chronic poverty and seasonal migration. They have roots in their lands, just like the trees, and invest in agricultural improvements, diversification, and education. In contrast, farmers in the control group still rely on seasonal migration for most months of the year. The study highlights the importance of addressing the underlying causes of distress-induced seasonal migration, such as chronic poverty. By creating alternative income sources at home, the transition from distress to selective migration can occur. Spillover effects of the program include enhanced local economies, providing non-participants with employment opportunities nearby and reducing their dependence on seasonal migration as well. By addressing the root causes and providing alternatives to seasonal migration, programs such as the Wadi can potentially break the cycle of poverty and exploitation of the rural poor in India and elsewhere.

### 2.7 Synopsis, Contribution 3

Many smallholder farmers worldwide live in marginalized rural areas, struggling to make a living. Over three billion people depend directly on soil and land, which are increasingly degraded natural resources. In India, the rapid depletion of forest resources has severely threatened food security for the most impoverished, particularly indigenous tribal groups. These families own small plots of land, growing rainfed subsistence crops that barely meet their needs. As a result, they migrate seasonally in search of wages, often under exploitative conditions, and remain stuck in poverty. The factors that contribute to this situation include degraded farmlands with little topsoil and organic carbon, deforestation, shifting cultivation practices that cause soil erosion, and water scarcity. Additionally, lack of capital or alternative employment opportunities, indebtedness, financial illiteracy, poor knowledge of improved agricultural practices, lack of diversification, and low educational levels perpetuate the low level of development across generations. Poverty alleviation, rural agricultural development, and combating of environmental degradation are significant challenges, and these issues are expected to worsen due to climate change.

Many projects, such as afforestation, attempt to halt soil erosion and environmental degradation. However, many fail because they exclude or even worsen the vulnerability of impoverished people. The negative tradeoffs with food security are often not considered as well. Nature-based solutions—such as agroforestry, which combines cultivating crops or pasture with growing trees—are better for food security and still sequester carbon. Evidence of successful projects to inform investments and meet SDGs is needed, but there is a lack of rigorous scientific assessment of the impacts and effectiveness of trees regarding a holistic beneficial effect on livelihoods and the environment.

The Wadi program develops orchards to lift people out of poverty and is an example of a more holistic approach, combining environmental restoration with poverty alleviation. Recognizing smallholders' attachment to their lands, the program supports families in establishing a Wadi on 1 acre of wasteland for 4–5 years. Tree varieties, such as mango and cashew, are selected, based on their agro-climatic suitability and market potential, in consultation with the families. It involves soil and water conservation measures and capacity building to transform wastelands into productive lands, benefiting the environment and the livelihoods of the participating smallholders.

A mixed-method approach was used in this study. Interviews were conducted with participants, non-participants, NGOs, and other stakeholders. Based on this qualitative data, a quantitative survey was developed, covering various topics, including household demographics, work/migration, farming, income, education, health, and more. The research design involved comparing farmers who had varying numbers of trees, keeping other factors as equal as possible. The study was conducted in four Indian states: Rajasthan, Maharashtra, Gujarat, and Karnataka. In total, 1,860 households were surveyed, including 1,132 participants and 728 non-participants. The research design consisted of three groups: (1) participants in program villages, (2) non-participants in program villages, and (3) non-participating households in villages 5–20 km away from the program areas. The control villages were carefully selected to match program villages in terms of external factors.

We found that the presence of fruit trees had positive impacts on various aspects of life, divided into four areas: (1) economic benefits, (2) social benefits, (3) environmental benefits and climate resilience, and (4) local community and economy.

Economically, fruit trees increased income sources, house quality, income from farming, and overall income. They also improved creditworthiness and allowed farmers to invest in their lands and diversify their income sources.

In social aspects, fruit trees correlated positively with education levels for youth under 18 years old, better prospects for children, reduced hardship, and increased life satisfaction. Owning an orchard was perceived as a status symbol, and the farmers felt empowered by transforming their wastelands into productive assets.

Environmentally, fruit trees had positive impacts on water availability and productivity per unit area. They promoted soil conservation and reduced crop damage due to high winds. We also found anecdotal evidence supporting climate change resilience.

Regarding the local community and economy, positive correlations were found between the number of fruit trees and village meetings (i.e., community involvement), further expansion of orchards, and reduction in seasonal migration.

Additional analysis comparing farmers who planted orchards at different times showed that the greater the number of years since the establishment of the plantation, the higher the impacts. After approximately five years, fruit trees started bearing fruits, providing additional income and significant life changes. Productivity per unit area increased steadily over time, as the trees matured and the soil fertility improved. As the farmers became aware of the benefits of cultivating fruit trees and earned additional income, they chose to invest in additional trees.

# 3 Discussion

I scrutinize the development pathway that enables farmers from the most impoverished segments of society to transform wastelands into valuable assets, thereby breaking the cycle of resource degradation and persistent poverty. By combining the principles of horticulture, forestry, and intercropping on a single acre of degraded and underused land, a space-efficient multi-cropping system is established, providing both food crops for self-consumption and cash income. The concept is highly lucrative for replacing subsistence farming and poverty in rainfed, dryland, and arid agro-ecosystems. This is especially significant, given that Indian agriculture is confronted with various challenges and limitations due to the rising population pressure, increased demands for food, natural resource degradation, and climate change (Dhyani et al., 2013).

Addressing poverty alleviation and environmental restoration in a comprehensive manner can lead to sustainable outcomes and a wide array of positive impacts and transformations across various aspects of life. These transformations include the following:

1. Environmental benefits and climate resilience. Planting fruit trees on degraded wastelands enhances the ecosystem without disrupting existing crop patterns, as only fallow land is cultivated. Moreover, the approach offers potentials for climate change adaptation and mitigation. My findings indicate the need for further research on the specific Wadi composition that yields the most successful output and exhibits the greatest climate resilience in different geographic areas. I discovered anecdotal evidence of the Wadi program’s positive effects on groundwater levels and soil quality; more research in this area would be desirable.

2. Economic benefits. Direct income effects are vital, particularly for the chronically poor. The diversified nature of the Wadi program creates multiple income streams, acting as a safeguard against the concentration of excessive risk on a single survival option. Income diversification is not just about earning more money but also serves as insurance against natural disasters and unfavorable market trends. Many farmers perceive an established Wadi as a kind

of pension, providing a steady income source even with low-intensity cultivation. With sustainable incomes and year-round job security on their own lands, farmers no longer need to resort to distress migration. Instead, they invest in their lands, adopt new technologies, and diversify. Seasonal migrants who were previously exploited are transformed into agricultural entrepreneurs. The program has profoundly changed the lives of impoverished farmers, and even young people are becoming enthusiastic about farming again.

3. Social benefits. The economic improvement and stabilizing effect of fruit trees replace the struggle for survival with stable, dignified lives. Beyond economic gains, enhanced food security, nutrition, and health, intangible social benefits emerge in the form of reduced hardship, increased confidence from expanded knowledge and skills, and improved education levels, as families can now focus on their children's education due to stable and secure lives in their local village. In contrast, farmers in the control group still primarily rely on seasonal migration.

Seasonal migration is a multifaceted phenomenon. It is essential to recognize seasonal migration as part of diverse livelihood strategies, moving beyond a narrow economic perspective. I emphasize the importance of addressing the underlying cause (i.e., chronic poverty) of distress-induced seasonal migration. For many migrant workers, seasonal migration is a defensive coping strategy that persists even though it does not increase their incomes or security but perpetuates their dependency by only servicing high-interest, subsistence-related debts. Creating alternative income sources at home is crucial to enable the transition from distress to selective migration.

4. Local community and economy. Benefits extend beyond orchard-owning households, transforming the entire local community. The agricultural activities invigorate the local economy, leading to overall market and agri-business growth and creating direct and indirect local employment opportunities. Another positive spillover effect is the widespread development of Wadis without external assistance.

However, this transformation requires substantial support and does not occur overnight. Five primary factors are identified as essential for achieving these multidimensional positive outcomes. (1) The program adopts a holistic approach with a well-defined central theme, as well as significant built-in flexibility. (2) It addresses area-specific needs by seeking options for rural communities in their local resource bases, rather than searching for solutions outside their villages. (3) The program involves smallholders themselves at every stage of the development process. (4) It provides initial financial support. (5) The program focuses on simple, affordable technologies.

This agricultural development initiative can serve as an exemplary model for broader replication. Given that rainfed agriculture constitutes a substantial portion of the lands and the total production in Africa, Asia, and the Pacific, diversifying into horticultural crops could bring prosperity and nutritional security to other rural communities. This approach allows more efficient uses of small landholdings, limited water resources, and high labor-to-land ratios, fully leveraging family labor and generating off-farm employment.

I examine the potential for sustainable intensification in the natural resource degradation and human vulnerability nexus. The knowledge gained can contribute to the design of future programs in order to lift smallholders in other areas out of chronic poverty as well. In the past, farmers were impoverished, and villages were deserted for much of the year. Now, smallholders have transformed wastelands into valuable green assets, becoming firmly connected to their lands, just like the trees they planted. The Wadi program has dramatically improved the lives of impoverished smallholders, allowing them to break free from a vicious cycle of poverty, resource degradation, and seasonal migration.

# 4 Contribution 1

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## Escaping chronic poverty:
## Long-term impacts of an agricultural development program

There is a need for groundbreaking initiatives to come to the rescue of the world's rain-fed regions, especially in the face of the current climate and food crises and the associated reversal of previous advances in poverty reduction. However, there is little evidence of successful programs, which can inform the development of proactive policies to meet these urgent challenges. Can sustainable agricultural intensification enable marginalized, smallholder farmers to break out of chronic poverty? In this study, we scrutinize the Wadi concept, an integrated farming system that includes water resource development, soil conservation, cultivation of fruit trees, and intercropping on degraded land. We use a mixed-methods approach that involves surveying 1,860 households, which were randomly sampled from a population of 188,231 participants across four Indian states, encompassing a variety of geographical regions. This is the first investigation into the effects of integrated farming systems on livelihoods on such a large scale and spanning 23 years. We compare the household participants of the program with the non-participants and run a linear regression analysis, *ceteris paribus*, comparing farmers who established integrated farming systems at different points in time over the period 1990–2017. Significant progress in several socioeconomic factors can be observed, such as higher incomes (the annual income of a typical participant has increased from INR 30,000 to 100,000 or even more), diversified income sources, positive life changes, higher life satisfaction, and better perspectives for children, as well as environmental benefits. The Wadi program's effectiveness in providing sustainable development pathways implies benefits to be gained from scaling it up. By thoroughly assessing its potential to help farmers escape chronic poverty and build resilience, this study provides evidence of the Wadi concept's success that can enrich the science-policy dialogue on development programs.

**Keywords:** Chronic poverty, income generation, agricultural development, integrated farming system, resilience, sustainable intensification, India, Wadi

**Declarations of interest:** none

### 1 Introduction

In light of the current climate and food crises and the associated alarming reversal of poverty alleviation (World Bank, 2020), there is an urgent need for land use policies to build the resilience of smallholder farmers. Three billion people, roughly 75% of the world's poor, live in rural areas and derive the major portion of their incomes from agricultural activities (World Bank, 2018, 2020). In India, the agricultural sector provides direct employment to more than 50% of the nation's workforce. Small and marginal farmers with landholdings of less than 2 ha comprise 82% of all agricultural labor, reflecting high land fragmentation and low economies of scale (FAO, 2022). Mainstream extension and agricultural support services fail to meet farmers' needs, limiting their capacity to access improved production inputs and technology (Singh et al., 2020). A typical family practices rain-fed agriculture, with few inputs and technologies. Unable to ensure their livelihoods with their meager harvests, most farmers migrate seasonally with their families to work elsewhere, typically under exploitative conditions, for several months every year. They are caught in a poverty cycle that perpetuates the low standard of living across generations (Asadullah & Yalonetzky, 2012; Mehta & Shah, 2003) and persists (Thorat et al., 2017), even though the Government of India follows affirmative action policies and despite Indians in general profiting from increases in wealth. ,

Many programs and efforts have been initiated in the past to eradicate rural poverty, but the results have often been disappointing (Ademola et al., 2018; Bhaumik, 2008; Bjornlund et al., 2020; Pittock et al., 2020; Roumasset, 2007; Wiggins, 2014), leading to growing dissatisfaction with the performance of many of the agricultural projects and programs (Roumasset, 2004). Development practitioners widely agree that rural agricultural projects are among the development projects that are the most challenging or even prone to fail. In their survey of the past century's literature on agricultural development, Barrett et al. (2010) concluded that knowledge about how to foster rural development remained incomplete, limiting the ability to pursue it.

Especially in challenging places where highly vulnerable people and highly degraded lands are interconnected by the 'natural resource degradation and human vulnerability nexus', projects might exacerbate the vulnerability of poor resource users if they fail to involve the people or benefit some families while harming others (Coleman et al., 2021; Ramprasad et al., 2020; Rozelle et al., 2000). In an evaluation of their own projects that apply natural resource management practices, the World Bank concluded that they failed to sufficiently tackle the vulnerability of people, who depend on natural resources (Independent Evaluation Group, 2021). A study by Turner (2021) examined projects as part of the larger goal of the Great Green Wall, a visionary effort aimed at restoring depleted lands and minimizing the vulnerability of the poor smallholders in the Sahel. It revealed that some of the most vulnerable were either neglected or excluded, and overall, little attention was paid to the improvement of their livelihoods. Bhattacharya et al. (2010) examined the insights gained over twenty years of Joint Forest Management (JFM) in India. A major drawback was the lack of people's participation. Worsdell and Sambhav (2020) explained that afforestation efforts in India resulted in the forced eviction of communities from their traditional lands, leading to homelessness and adverse impacts on half a million tribal and forest-dwelling people in India. Moreover, in global mitigation policy, the unfavorable tradeoffs with food security are frequently overlooked (Doelman et al., 2020). Oxfam (2021) states that commonly used offsetting measures such as reforestation and planting new forests can put food security at risk. Instead, it is better to use nature-based solutions like agroforestry, because these sequester carbon and at the same time allow people to use the land for food.

As there are only a limited number of examples of agricultural initiatives that have achieved long-term success, and due to continued doubt regarding financial backing for rural farming programs, evidence of potential success is urgently needed. "Failing to learn the lessons of the history of development policies may have doomed us to repeat them" (Roumasset, 2007, p. 36). Despite the fact that the past decade witnessed a movement toward evidence-based policy and increased emphasis on learning from evaluations (Maredia, 2009), the available literature to date provides little systematic guidance for agricultural policymakers. Standard evaluations of projects managed by development banks are mostly conducted in the form of short field visits and rapid rural appraisals, which cannot be compared to scientific analysis based on quantitative data. Furthermore, most impact assessments are small-scale, short-term, or very context-specific types; only a few reports try to generalize findings and provide evidence of what works in agricultural development, such as Millions Fed: Proven Successes in Agricultural Development (Spielman et al., 2009). Despite billion-dollar investments, there is relatively little knowledge about the net impact of most programs (Center for Global Development [CGD], 2006). As the Development Impact Evaluation (DIME, 2021) states, "[t]he Sustainable Development Goals (SDGs) urge the international community to make the investments needed to double agricultural incomes of small-scale food producers. However, current yield trends suggest a need for path-breaking innovations to come to the rain-fed areas of the world to meet this target. Astonishingly little evidence exists to rigorously inform the investments needed to meet this urgent goal."

We address this knowledge gap by rigorously scrutinizing the Wadi program, which has anecdotal evidence of success and is a potential bright spot in this otherwise bleak picture. Can it transform the livelihoods of chronically poor smallholders? Initiated in the early 1990s, it encourages integrated farming practices by developing water resources and orchards and has since been rolled out in several Indian states, covering geographically diverse regions. There is reason to expect that the Wadi concept may provide guidance for future development efforts, which we describe in the next section. However, no scientific assessment of impacts has been undertaken so far. We use mixed-methods, including a survey of 1,860 randomly sampled households (from over 188,000) in Rajasthan, Gujarat, Maharashtra, and Karnataka, to assess both the impacts of the Wadi program and the underlying causal relations that likely drive them. To foreshadow our findings, we discover significant improvements across a variety of parameters – higher incomes, higher life satisfaction, perceived positive life changes, as well as better long-term perspectives – when comparing household participants of the Wadi program with non-participants. The objective of our study is to provide the much-needed evidence of program success to inform the science-policy dialogue about development programs by rigorously assessing the Wadi program's potential to help farmers escape chronic poverty and to synthesize key lessons. This way, it can serve as a role model for future agricultural development programs.

## 2 Background: Integrated farming and the Wadi program

In terms of indirect evidence, there is reason to believe that integrated farming systems, such as those promulgated by the Wadi program, generally play an important role in rural agricultural development. Argade and Wadkar (2013) reviewed the literature on integrated farming systems' contribution to the achievement of sustainable rural livelihood security and noted the inevitability of a paradigm shift in research toward small and marginal holders and the role of integrated farming systems. They pointed out that almost all Indian farmers adopted some sort of integrated farming system; however, without scientifically designed and appropriate farming models, they remained mostly subsistent and rather uneconomical, unable to harness the benefits. Especially for small and marginal farmers, integrated farming is considered the most powerful tool for sustainably enhancing prosperity, employment, and nutritional security, as well as fostering regional economic growth and resilience to climate change (Argade & Wadkar, 2013; Singh & Dhayani, 2014). Sharma et al. (2017) assessed the challenges and opportunities of agroforestry systems in India. They did not explicitly mention the Wadi program but included agri-horticulture, defined as "fruit orchards/fruit tree-based cropping systems" as well as "horti-pastoral systems in hilly orchards for soil conservation" (based on Dagar et al., 2014). There is the possibility to increase the agroforestry area, particularly on degraded land and wasteland, according to the Central Agroforestry Research Institute (CAFRI, 2015). But even so, there has not been enough study done on agroforestry concepts. In India, most studies are of short-term nature and have been conducted at research stations on relatively small plots and/or in laboratories, with few ecosystem or landscape-level studies. (Sharma et al., 2017).

In this study, we analyze the Wadi program in India. Wadi translates to "fruit orchard" in the Gujarati language, since the Wadi program first took hold in Vansda, Gujarat in the 1990s. From then on, the concept has been widely replicated in 12 districts of Gujarat ,18 districts of Maharashtra, 15 districts of Rajasthan, and 8 districts of Karnataka, with almost 200,000 participating households.

The program's design begins by acknowledging the strong emotional connection smallholders have to their land. Typically, each family receives assistance for four years to establish a Wadi on one acre of land that is considered unsuitable for rain-fed crop cultivation. The main focus of the program is to assist families in growing fruit trees. The families are consulted on which fruit tree varieties, such as mangoes and cashews, to plant, based on the local climate and market potential. Usually, a block of 50 to 60 fruit trees is planted with seasonal intercrops in between. To protect the area from open-grazing cattle, the block is enclosed by 250 to 400 multipurpose forest tree species and a thorny live hedge, as shown in Figure 1. Depending on the location, family housing and the water source might be within the Wadi or in its surroundings.

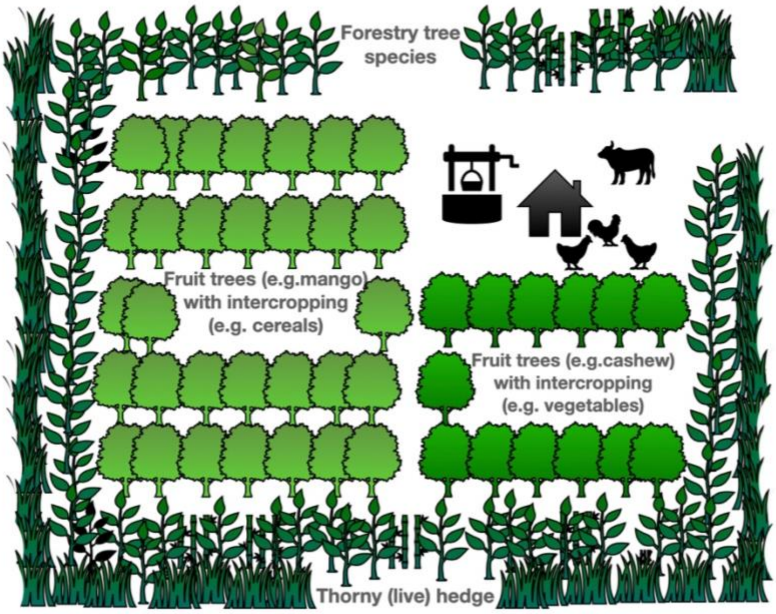


Figure 1: Schematic depiction of a Wadi

Because these plantations are set up on degraded land in places prone to soil erosion and water shortages, soil and water conservation, as well as water resource development, are critical. Despite receiving moderate to high rainfall, most precipitation is limited to the monsoon season, and due to the steep and rocky terrain, most of the water is lost, potentially washing away the topsoil in the process. Soil conservation measures have the objectives of stopping further degradation and improving soil fertility. By reducing the velocity of runoff water, the water has more time to trickle into the ground and recharge the aquifer underneath. The intent is to reduce the problem of drinking water scarcity, as well as to ensure a sufficient supply of water to the cultivated plants, especially during the growth stage in the summer. Depending on the site-specific needs, new decentralized water resources are developed, or existing ones rehabilitated. The measures are planned through interactions with the respective farmers and customized to each Wadi plot.

Beyond tree planting and water conservation and development, another important measure is capacity building. This reflects the fact that smallholders have rich traditional knowledge but are not acquainted with the management of horticulture and cash crops. Capacity building is implemented through regular training sessions and field demonstrations. This also involves creating cooperative community organizations to more effectively address difficulties in marketing agricultural goods and to guarantee fair prices. These are set up and guided in aggregation, marketing, value addition, and forward integration. This creates local job opportunities, such as mango trading or cashew processing, from which landless people profit as well.

One more critical component is the initial financial assistance. Due to the fairly long gestation period of 3-5 years, during which no considerable revenue is expected, except from intercrops (implying an irrigation system is available), farmers get compensation for working on their own land. This allows them to stay on their farms rather than turning to seasonal migration for subsistence.

Table 1: Measures of the Wadi program.

| **Measure** | **Description** |
|---|---|
| Agri-horti-forestry | Development of orchards in family-owned wasteland plots of approximately one acre, along with intercropping and plantation of several multipurpose tree species along the boundaries of plots |
| Soil and water conservation | Small dams and mini check dams, earth and stone bunding, platforms, trenches and ring basins/wells, gully treatment, seasonal mulching, soil loosening, installation of diffuser systems |
| Water resource development | Group wells, springs, small check-dams, micro-lift irrigation systems, water harvesting tanks, gravity-based irrigation systems, pot drips (low-cost alternative for drip irrigation system) |
| Capacity building | Expertise in Wadi maintenance, improved agricultural practices, irrigation techniques, water management, composting, value addition to farm produce, mango grafting, access to structured finance, knowledge of modern supply chain techniques, preventive health measures |
| People's organizations, Cooperatives, Self-help groups | Providing institutional base for community participation, women empowerment, building agri-businesses to ensure good returns to producer-families, generating a premium through value addition, e.g. processing of mango pickle, pulp jam and cashew |

So far, no rigorous scientific study of the Wadi program's impact and effectiveness exists. However, anecdotal and indirect evidence suggests that the program has been successful. Trebbin and Hassler (2012) examined the actions of a cooperative established under the Wadi program, which was involved in processing and marketing mangos and cashews in a specific region. They conducted a set of 45 interviews with key stakeholders, including six members of the cooperative. Overall, they found that the stakeholders were positively impressed with the actions of the cooperative, and this reflected well on the Wadi program more generally.

## 3 Methods

### 3.1 Mixed methods

We employed a mixed-methods approach, beginning with qualitative evidence and progressing to quantitative evidence to determine important findings before concluding with further qualitative evidence to expand our knowledge of the mechanisms at work.

We began with field visits, participatory rural appraisal, participant observation, and focus group discussions with village representatives and women's self-help groups. We also used techniques that accounted for illiteracy, such as ranking and drawing. We conducted interviews with various stakeholders, including participants, non-participants, local and international experts, NGO representatives, ministers, health professionals, teachers, bank professionals, and representatives of tribal institutes and development agencies. Based on this qualitative data, we developed a quantitative survey that was conducted in four Indian states, face-to-face. The survey lasted between one and two hours and asked questions about several socioeconomic indicators and aspects of farming, food security, seasonal migration, education, and well-being. We also included questions about the respondent's capability to understand of the questions, the geographic context, and an open question for remarks and GPS data collection -for additional insights, validity and reliability checks. This questionnaire was developed in an iterative process, including rigorous field-testing and translation. We conducted two training sessions for the enumerators, who were familiar with the local dialect and context. As part of the training, they practiced how to use the Open Data Kit (ODK) software (Hartung et al., 2010) on their smartphones. By utilizing mostly (closed) multiple-choice questions and enabling direct digital input of the data, potential errors and the need for extensive data cleaning were minimized. After the survey was completed, the interviewers discussed their personal experiences, challenges and solutions in a report. During analysis, we conducted further interviews with stakeholders or experts as needed for verification or clarification.

### 3.2 Research design and sampling

First, we explain here the implementation procedure and program's rules for selecting participants because these rules allowed us to pick a robust method and counterfactual group. The Wadi program was gradually implemented in different geographical areas, i.e. in form of a randomized rollout. More precisely, all eligible beneficiaries in a particular village or region were covered, before transitioning to the next one. The program was introduced by organizing meetings in villages and hamlets and facilitating exposure visits, ensuring that all eligible participants were provided with an equal chance to participate. Automatically, this system has produced conditions comparable to a randomized evaluation design that can provide good internal validity and can rely on weaker assumptions compared with other methods (Gertler et al., 2016). All villages situated in the program zone were provided with the option to enroll in the program during a particular year, whereas the villages located outside the area had to wait for the program to expand further. As a result, these households and villages located immediately beyond the program's coverage area, who had not yet been given the chance to participate, were used as control villages. Consequently, we were able to specify three different control groups (control villages, recent participants, and non-participants in Wadi villages) to compare with the treatment group, as depicted in Figure 2 and described below.

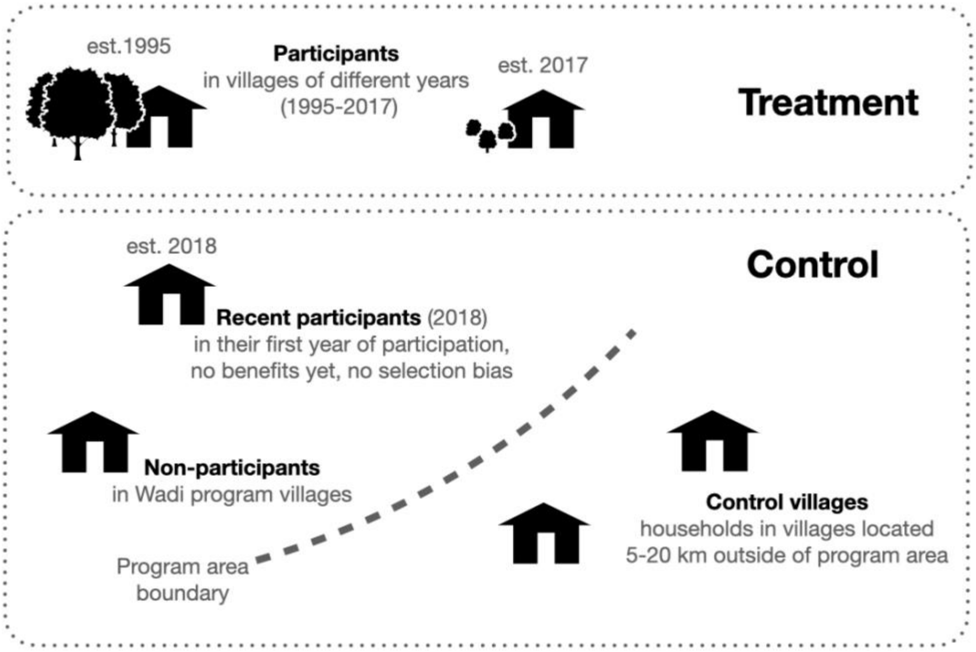


Figure 2: The research design consists of one treatment group (n=1132) and three control groups: recent participants (n=202), non-participants in program villages (n=380) and households in control villages (n=146).

**Recent participants:** These randomly sampled households are already enlisted as participants but have not received any benefits yet. There is no self-selection bias as they are technically participants; however, the program has not had any impact yet, which makes them an ideal counterfactual group.

**Non-participants in Wadi program villages:** These are households that were randomly selected and who chose not to take part in the program when it was introduced in their villages.

**Households in control villages:** These households were randomly sampled from villages situated 5-20 km away from the program areas. The choice of control villages was made after consulting with local experts and based on specific criteria to ensure that their circumstances were similar to those of the program villages before the program began, and to take into account any external factors.

The survey was conducted among 1,860 households, which were randomly sampled from a total population of 188,231, made up of all households that participated in the program across four states. Of the 1,860 households surveyed, 1,132 were program participants, while 728 were non-participants. For the sampling of the participants, the lists from the project implementation were available; for the non-participants, the lists of inhabitants were provided by each village administration. Random sampling was conducted in Excel. In case the residents of a sampled household could not be located during the first and second visits of the interviewer or refused to participate in the survey, a backup shortlist of randomly sampled households was prepared to ensure that the required number of households was interviewed.

### 3.3 Analysis

We conduct a number of analyses to fully explain the causal relationship between program participation and its effects. First, we analyze income and the number of income sources by comparing treatment and control groups (using the t-test and the Wilcoxon rank-sum test). Then, we analyze the increase in income and income sources *over time.* We appreciate the fact that the program has been implemented in different villages at different times over a 23-year period because this makes it possible to analyze a trend in possible impacts of the program by (*ceteris paribus*) comparing farmers who have established their Wadis at different points in time – from 1995 to 2017. In this assessment of development over time, the time course is represented by the explanatory variable *years since participation*, where control households are considered to have 0 years since participation and each treatment household has its specific number of years since participation. This enables an understanding of the trend as a development pathway and constitutes a valuable addition to the classic statistical analyses of treatment versus control groups. Furthermore, we use multiple regression analysis to control for other factors that are potentially confounding. With this, we analyze income and the number of income sources, as well as positive life changes over the last 5 years, life satisfaction, and perceived opportunities for children. These findings are based on questions, answered on a 5-point Likert scale, to examine the farmers' perceptions on whether (1) life has changed in the last 5 years, (2) they are satisfied with life, and (3) their children and grandchildren will have more opportunities than they have had themselves. Any statistical result is cross-checked with our qualitative findings and verified with stakeholders, while our quantitative analysis confirms the qualitative conclusions.

## 4 Results

We want to know whether the Wadi program can transform livelihoods of chronically poor smallholders. For these farmers, income is a key factor of well-being, as it can help fulfill many urgent needs, such as food, shelter, or education. Our statistical analysis and field verification showed that the program participants had increased their incomes. On average, they generated an annual net income of INR 73,000 (EUR 920) compared with INR 40,000 (EUR 500) without intervention (t-test, $t\ (1774.2) = -12.96$, $p < 0.001$). Since outliers in income were found in both groups, the test results were also confirmed by nonparametric testing (Mann-Whitney ($W$) = 254480 and $p < .001$). With $d = 0.59$, a moderately strong effect presented itself (Ellis, 2010). This significant increase in income as a positive result also applied to families with small landholdings of 1 to 2 acres. Households with 3 to 5 acres, fertile soils, and good management profited even more and reported net incomes of INR 200,000. In exceptional cases, for example, where farmers started an additional business of producing mango seedlings, incomes of up to INR 400,000 were earned.

As illustrated in Figure 3, this significant difference can also be observed when scrutinizing the control groups separately (Figure 3, left graph) ($F\ (3, 1787) = 55.04$, $p < .001$). On average, the participants' annual income was almost twice those of the control groups (i.e., households in control villages, non-participants in program villages, and recent participants). The number of income sources, on average, was almost 25% higher.

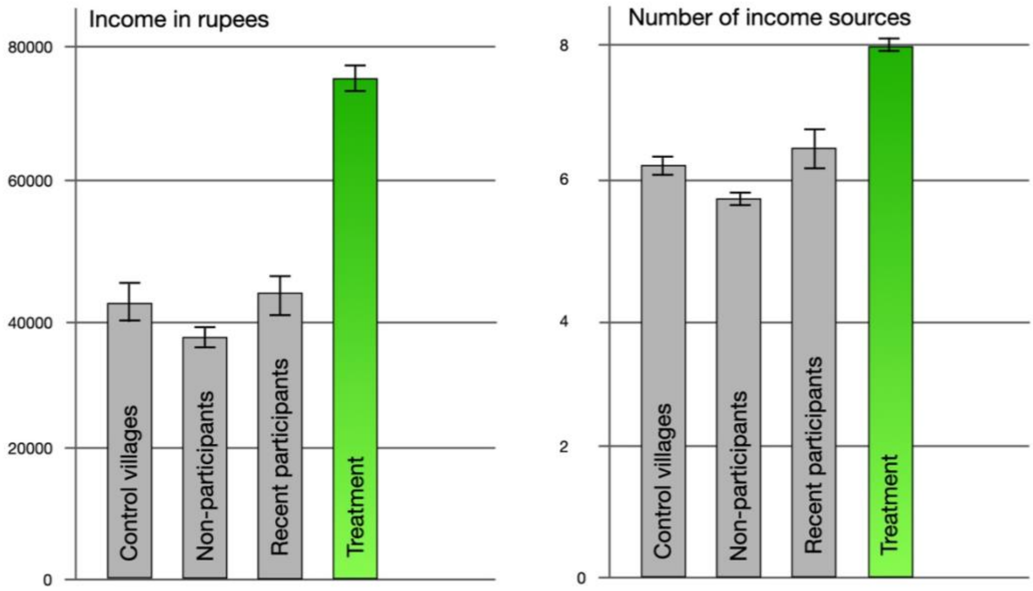


Figure 3: Average income in rupees and number of income sources of control groups and treatment. Whiskers represent standard errors.

A small difference among the three control groups can be noted and explained. The recent participants (i.e., the control group that just signed up for the program but did not receive any benefits yet, thus ruling out any selection bias) earned a similar low income on average, as the farmers did in the control villages, located just outside the program area, confirming the high similarity between the control villages and the program villages before the program started. The non-participants in the program villages (i.e., people who theoretically had the opportunity to participate but did not join) had an even lower income, on average. This raises the question of barriers to participation, which is beyond the scope of this paper. Overall, some people who did not participate were among the most marginalized and disadvantaged, in line with their being the control group with the lowest income, as depicted in Figure 3.

Regarding the number of income sources (Figure 3, right graph), similar differences between the control groups and the treatment groups were found. The household participants of the program had, on average, 8 different income sources, while the control groups had around 6. It should be noted that the information on income sources was collected per category; for example, tomatoes, onions, and cucumbers were grouped under the category *vegetables* and were therefore counted as one income source. Thus, counting the different vegetable species grown would result in even higher numbers of different income sources.

Figure 4 shows the Wadi program's effects on income and income sources over time. The left-hand graph illustrates a typical participating household's increase in annual income from INR 30,000 to INR 100,000 or even higher. The right-hand graph shows the increase in the number of income sources, that is, the typical participating household's diversification of its income sources over time.

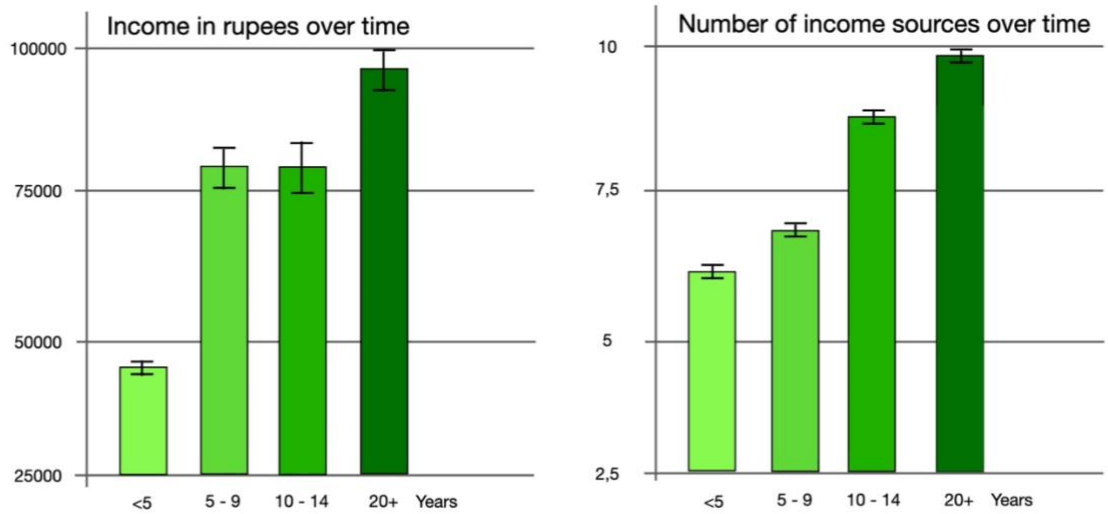


Figure 4: Increase in income and income sources *over time*. The x-axis categories indicate number of years a participating family has been active in the Wadi program.

We found that the farmers' incomes continued to increase as a result of the intervention, even though the support ended after four years. This finding is consistent with the increase in harvest over time, due to the trees' growth. The farmers also continued to apply their newly acquired knowledge on improved farming techniques, as well as their newly adopted technologies, such as drip irrigation, enabling them to generate up to three harvests per year. Some farmers currently perceive themselves as agricultural entrepreneurs, whereas before their participation, they were impoverished smallholders.

We observed that many farmers developed an entrepreneurial spirit and diversified their income sources over time. The right-hand graph in Figure 4 illustrates that diversification especially takes off after a few years, when the establishment of the Wadi is completed. The farmers then rely on up to 10 income sources. In the questionnaire and the quantitative analysis, different types of vegetables were counted as one income source. Nonetheless, our qualitative data showed that most farmers cultivated several different types of vegetables and therefore diversified their income sources even more than the quantitative results indicated.

The results depicted in Figures 3 and 4 are in line with the multiple regression analysis results shown in Table 2; the regression analysis allows us to control for other factors that are potentially confounding.

| | *Dependent variable:* | | | | |
|---|---|---|---|---|---|
| | Income | | | Income sources | |
| | (1) | (2) | (3) | (4) | (5) |
| Treatment | 29,422.570*** | | 22,542.660*** | 1.206*** | |
| | (3,316.922) | | (5,405.337) | (0.122) | |
| Years since participation | | 1,678.500*** | 551.427 | | 0.129*** |
| | | (210.865) | (342.175) | | (0.007) |
| Own landholding | 5,279.841*** | 5,365.725*** | 5,250.397*** | 0.091*** | 0.086*** |
| | (924.321) | (928.018) | (924.076) | (0.030) | (0.029) |
| Sum of years of education adults | 872.479*** | 916.702*** | 879.116*** | | |
| | (125.716) | (125.993) | (125.725) | | |
| Hours of electricity | 1,114.800*** | 1,082.259*** | 1,086.558*** | 0.041*** | 0.036*** |
| | (209.532) | (211.156) | (210.167) | (0.007) | (0.007) |
| Own wadi expansion | | | | 0.921*** | 0.494*** |
| | | | | (0.120) | (0.116) |
| Distance to secondary school | 199.765*** | 135.741* | 177.465** | 0.020*** | 0.015*** |
| | (69.313) | (70.267) | (70.649) | (0.002) | (0.002) |
| Distance to nearest water source | -8,735.965*** | -8,989.842*** | -8,695.733*** | -0.187*** | -0.169*** |
| | (1,602.511) | (1,607.962) | (1,601.968) | (0.053) | (0.050) |
| Total people | -2,236.985*** | -2,576.634*** | -2,353.634*** | 0.121*** | 0.104*** |
| | (834.387) | (839.368) | (837.138) | (0.026) | (0.025) |
| Sum of total months of migration per year | 4,934.238*** | 4,605.729*** | 4,865.366*** | 0.120*** | 0.108*** |
| | (434.299) | (433.768) | (436.198) | (0.014) | (0.014) |
| Constant | 9,117.577 | 19,064.860*** | 10,959.860 | 3.996*** | 4.256*** |
| | (7,067.149) | (6,919.316) | (7,155.803) | (0.234) | (0.216) |
| Observations | 1,743 | 1,743 | 1,743 | 1,743 | 1,743 |
| $R^2$ | 0.198 | 0.191 | 0.199 | 0.299 | 0.369 |
| Adjusted $R^2$ | 0.194 | 0.187 | 0.195 | 0.296 | 0.366 |
| Residual Std. Error | 65,533.750 (df = 1734) | 65,812.490 (df = 1734) | 65,503.600 (df = 1733) | 2.160 (df = 1734) | 2.050 (df = 1734) |
| F Statistic | 53.426*** (df = 8; 1734) | 51.142*** (df = 8; 1734) | 47.822*** (df = 9; 1733) | 92.494*** (df = 8; 1734) | 126.562*** (df = 8; 1734) |
| *Note:* | | | | | *p<0.1; **p<0.05; ***p<0.01 |

Table 2: Regression models of (1) income in INR depending on treatment, (2) income in INR depending on years since participation (3) income in INR depending on treatment *and* years since participation, (4) number of income sources depending on treatment and (5) number of income sources depending on years since participation

As shown in Model 1 (Table 2) of this regression analysis, the variable *treatment* indicates that the average annual income of the participants is INR 29,423 higher than that of the non-participants. As presented in Model 2, each additional year in the program (*years since participation*) is associated with INR 1,679 additional income, significant at $p < .001$. With $R^2 = .191$ and $F (8, 1734) = 51.142$, $p < .001$, a significant and moderate variance explanation for the model can be noted. Model 3 reveals that when *treatment* and *years since participation* are both fed into the model as independent variables, *treatment* still shows a significant effect. Model 4 shows that the participants (*treatment*) have, on average, more than one additional income source compared with the control group members. Finally, Model 5 shows a significant increase in the number of income sources for every year of participation.

Besides *treatment* and *years since participation*, further factors are significant for annual income, as well as the number of income sources. Regarding the number of income sources, it should be noted that it is not the case that an entire additional income source is added every year, which is why fractions of 1 appear in Models 4 and 5 of the regression analysis (Table 2). On average, each additional acre of a farmer's *own landholdings* means an extra income of more than INR 5,000 per year. Each additional *year of education* completed by the adults in a household means an extra income of over INR 900 annually. Electricity also plays a role, as each additional *hour of electricity* leads to a yearly income increase amounting to INR 1,000. *Distance to secondary school*, a proxy for remoteness, shows, on average, a slightly higher income for more remote households. The variable *distance to nearest water source* indicates the importance of water; for every 100 meters less, the annual income is, on average, more than INR 8,000 higher. The analysis shows that more people in a household, *i.e. household size* (*total people,*) means generally less income but more income sources. The time that someone in a household spends on seasonal migration (*sum of total months of migration per year*) increases the household's annual income, on average, to more than INR 4,000.

The increase in income is further reflected in an improved standard of living. Qualitatively, many Wadi households have acquired electric appliances or other assets for the first time. Examples include pump set/irrigation pump, radio, television, mobile phone, bicycle or scooter, and livestock, such as oxen and/or dairy cattle, apart from home renovation or construction of new solid brick houses. Participants were able to generate cash income through fruit trees, while also meeting most of their food needs from intercropping and kitchen gardens, both of which were encouraged as part of the program. All this led to substantially improved food security and dietary diversity. Subsequent to participation, livestock has become an integral part of the household assets to meet food, meat, egg, animal power, and fertilizing needs.

While an increase in income can be used to finance many urgent needs of smallholders, money is not everything. Eager to find out more about the important but non-tangible aspects of life as well, we asked questions, answered on a 5-point Likert scale, to examine the farmers' perceptions on whether (1) life had changed in the last 5 years, (2) they were satisfied with life, and (3) their children and grandchildren would have more opportunities than they had themselves.

| | *Dependent variable:* | | |
|---|---|---|---|
| | Life changes | Life satisfaction | Children better future |
| | (1) | (2) | (3) |
| Treatment | $0.341^{***}$ | $0.288^{***}$ | $0.137^{***}$ |
| | (0.025) | (0.029) | (0.028) |
| Income | $0.00000^{***}$ | $0.00000^{***}$ | $0.00000^{***}$ |
| | (0.00000) | (0.00000) | (0.00000) |
| Own landholding | $0.017^{**}$ | $0.016^{**}$ | |
| | (0.007) | (0.007) | |
| Hours of electricity | $0.013^{***}$ | | $0.012^{***}$ |
| | (0.001) | | (0.002) |
| Own wadi expansion | | $0.137^{***}$ | |
| | | (0.028) | |
| Sum of total months of migration per year | $-0.006^{*}$ | $-0.017^{***}$ | |
| | (0.003) | (0.003) | |
| Topographic factor | | | $-0.131^{***}$ |
| | | | (0.021) |
| Water quality | | | $0.552^{***}$ |
| | | | (0.055) |
| Constant | $2.332^{***}$ | $3.634^{***}$ | $3.624^{***}$ |
| | (0.035) | (0.029) | (0.084) |
| Observations | 1,860 | 1,860 | 1,654 |
| $R^2$ | 0.190 | 0.152 | 0.174 |
| Adjusted $R^2$ | 0.188 | 0.149 | 0.172 |
| Residual Std. Error | 0.501 (df = 1854) | 0.517 (df = 1854) | 0.540 (df = 1648) |
| F Statistic | $87.255^{***}$ (df = 5; 1854) | $66.338^{***}$ (df = 5; 1854) | $69.576^{***}$ (df = 5; 1648) |
| *Note:* | | | $^{*}$p<0.1; $^{**}$p<0.05; $^{***}$p<0.01 |

Table 3: Regression models for positive life changes over the last 5 years, life satisfaction and perceived better future/perspectives/opportunities for children

As shown in Table 3, *treatment* has a positive impact on all three dependent variables. Across the three models, *income* is also highly significant, but due to the nominal value of the Indian rupee, the coefficients themselves are so small that only zeros are shown. Finally, the survey respondents' comment that they would rather farm than seasonally migrate for the same income is also reflected in Model 2, where life satisfaction is negatively correlated with *migration*. This is not surprising, given the often exploitative nature of seasonal migration. (For our analysis of the program's impact on seasonal migration, see Nienkerke et al., 2023).

We always analyzed all households together, as well as each state separately. Comparing the state-wise analyses, we only found small differences, similar to differences between villages and regions within states, which are not worth reporting here. In line with our qualitative data and field visits, the conditions and challenges faced by smallholders in these marginalized areas are similar, independent of state boundaries. Factors playing a role are part of the regression analysis, such as water availability. We found the same causal relationships in all areas and therefore took all states as one sample.

Taken together, this evidence shows that while control groups continue to live in poverty, the participants convert wastelands into productive assets, generate sustainable incomes, diversify their income sources, lead more satisfied lives, and report positive life changes and perspectives.

## 5 Discussion

Can a development program initiate a pathway that enables marginalized smallholders to break out of a vicious cycle of chronic poverty? The answer is yes. Our findings show that through the Wadi program, farmers from the poorest groups of society convert wastelands into profitable assets, thus breaking the cycle of resource degradation and chronic poverty.
Regarding our statistical analysis, it should be pointed out that if the control groups benefit from external development benefits, this means that the program's impact is even underestimated.

In the regression analysis, we discover that in addition to *treatment* and *years since participation*, various factors – *own landholdings*, *education of adults*, *electricity*, *remoteness*, *water availability*, *the number of people in the household*, and *the number of months of seasonal migration* – have a significant impact on both annual income and the number of sources of income. Even though farmers with 1-acre landholdings can substantially increase their incomes through program participation, farmers with more lands can cultivate more crops and, on average, earn even higher incomes. *Education* is neither a prerequisite nor a guarantee for success; however, educated participants are more likely to acquire new knowledge, adopt improved farming techniques, and manage their farming business successfully. *Electricity* and a *nearby water source* both facilitate irrigation, but this does not mean that constant electricity and water supplies automatically lead to an endless increase in irrigation, harvest, and income. Interestingly, *remoteness* (we use *distance to secondary school* as a proxy) has a small but significant positive impact, which means that remote farms perform better on average. This is in line with our qualitative findings that remoteness is not necessarily a drawback, despite more difficult market access. Remotely located farmers often focus more on their Wadis and take especially good care of them. Perhaps because they are less distracted or tempted by alternatives, which might provide quick but low earnings in the long term, compared with orchards. The impact of *family size* (i.e., the number of people in a household) can be diverse.

On one hand, a household with more members means more hands to help, on the other hand, there are more mouths to feed. Whether the members help or need help generally depends on the family's age composition; therefore, this factor should not be generalized, and we cannot discuss it in depth here. What is clearer is that on average, the more time spent on seasonal migration by a household member who is not needed in farming, the higher the amount of money that can be contributed to the household income from non-farming activities (for more details on the program's impact on seasonal migration, refer to Nienkerke et al., 2023).

Besides the direct effect of increased income, the program has many positive, indirect, somewhat intangible impacts as well. It stimulates the local economy by providing jobs – also for landless families. Twice the amount of employment per hectare of production is required in this integrated farming system compared with cereal crop production. Off-farm job opportunities are also created, for instance processing and marketing of cashew or managing the cooperative activities. As a result, a general growth of agri-businesses and markets can be observed in project areas. Social benefits include a rise in self-confidence, gained through newly acquired abilities and knowledge, women empowerment, and improvements in dietary diversity, health, and quality of life. Stakeholders speak of an atmosphere of confident hope, whereas before the program implementation, people were desperate. Owning a wadi is a status symbol, representing prosperity and security, as ancient kings and landlords had the capacity to invest in this type of agricultural activity, which has a longer gestation period yet appreciates in value year after year. Working hands-on to convert their own wastelands into valuable orchards helps the participants feel empowered and competent. This explains the happiness and strong emotional connection to the Wadi, as expressed by some women: "We can consider the Wadi our earning son who will stay with us forever." Many farmers view an established Wadi as a type of pension. Even when cultivated with a low level of intensity, it provides a steady source of income. According to a widow, she still cherishes the Wadi very much; even though she moved away to live with her son's family, she returns every year to harvest the fruits, which grow even with zero input. Furthermore, the trees exhibit good resistance to fluctuating rainfall; some farmers report a loss of yield from cereal crops over the past few years as a result of unusually dry periods during the monsoon season; in contrast, the fruit trees have sustained no damage.

Through the diversified nature of the Wadi program, multiple income streams are created. This acts as a hedge against the concentration of too much risk on a single survival option. The qualitative interviews clearly indicate that diversification of income sources is not only about generating more money but also an insurance against natural calamities and unfavorable market developments. This becomes especially relevant when taking the tragedy of the so-called suicide belt into account, where many farmers who incurred debts to invest in monocropping took their own lives after failed harvests. In contrast, Wadi farmers speak of diversification on various levels: seasonality, gestation periods, shelf life, and labor requirements. As a result, they can allocate resources more dynamically, optimize land use, and extend income generation to the whole year – even in rain-fed conditions. Before the program support, there was no income source within the village for several months per year, and the local farmers were forced to seasonally migrate for survival. Because families now have stable and secure lives in their local village, they can pay more attention to their children's education. The program has transformed the lives of poor farmers, and even youths have become enthusiastic about farming again.

Our results are consistent with the benefits of integrated farming systems highlighted in Argade and Wadkar's (2013) review. This is especially true in terms of productivity (Jayanthi et al., 2002), profitability (Behera et al., 2004; Jayanthi et al., 2009), sustainability (Lightfoot & Minnick, 1991), nutritional quality (Jayanthi et al., 2009), ecological protection (Jayanthi et al., 2009; Lightfoot & Minnick, 1991), employment and income throughout the year (Dwivedi, 2007; Mahapatra, 1992; Radhamani et al., 2003; Ugwumba et al., 2010), and resilience (Fraser et al., 2005). Our results offer something new by suggesting that a development program can stimulate integrated farming practices to achieve these benefits. One does not need to wait for farmers to adopt such practices on their own.

## 6 Conclusion and recommendations

While many agricultural projects fail, from scientific and social standpoints, the Wadi program appears to be a success. Despite small landholdings, initially low soil productivity, the lack of irrigation, and other resource constraints, small and even the poorest farmers are able to increase their incomes, improve their livelihoods, enhance their life satisfaction, and expand their perspectives substantially. However, these do not occur overnight but need strong support. These require financing, good quality inputs, technical knowhow to adopt improved practices, and an organization, such as a cooperative, to collect, grade, process, and market the produce.

It has become evident that complex problems require holistic solutions (see Nienkerke & Patt (2022) for details on the program's holistic approach and its broad range of positive transformations). It is equally essential to involve the beneficiaries themselves at every stage of the development process, as well as provide the initial financial support. The investment is well worth it, as the return on investment is high, and the economic life is up to 100 years.

Our rigorous assessment has enabled us to not only generate knowledge that can help the development of future programs but also identify central success factors, as follows:

- Building good relationships with local people, mutual trust, and transparency
- Involvement of participants in management since the beginning
- Extension service through local field guides instead of external technicians
- Potential participants' exposure visits to established Wadis
- Disbursement of cash component directly to each participant's bank account
- Protective irrigation during gestation of fruit trees
- Live hedge against free-grazing cattle
- Simple, affordable technologies
- Well-defined central theme but with considerable built-in flexibility
- Options for rural communities within their own local resource bases rather than looking for answers outside their villages
- Replicability across various socioeconomic conditions and agro-climatic zones
- Better market access through cooperatives

The Wadi model can be scaled up to efficiently use limited water resources, small landholdings, and high labor–land ratios in rain-fed, arid agro-ecosystems elsewhere, too. In India, 74% of the farmers hold less than 2 ha of land. It is also estimated that India has roughly 10 million ha of under-utilized wastelands, which can be brought under the Wadi program without curtailing the areas dedicated to food crops. Globally, rain-fed agriculture also accounts for sizeable portions of the lands and of total production in the continents of Africa, Asia, and the Pacific.

Our results suggest the need for further investigation into the particular Wadi composition that provides the most successful output and is the most climate-resilient in other geographic areas. Further areas for valuable research include the program's impact on seasonal distress migration. Many participants said that they were able to stop migrating; however, this is beyond the scope of this paper. We found anecdotal evidence of the Wadi program's positive impacts on groundwater levels and soil quality; unfortunately, without robust measurements, this cannot be proven as of now.

Gandhi believed in human dignity. Every person has the right to live in dignity, but in the case of the poor, this gets lost in their struggle for survival. The Wadi model can provide a reliable source of livelihood for the rural poor throughout the year in order for them to escape the vicious cycle of chronic poverty. This has become particularly crucial in the face of the present food and climate crises.

**Annex: Core topics of the survey**

Assessment of location and Wadi:

- Year of wadi establishment
- Number of (fruit) trees
- Survival of trees
- Wadi expansion
- Water availability after Wadi

Farming and landholding,

- Cultivation of crops (for each season)
- Quantity in kg (incl. self-consumption)
- Price/kg
- Livestock
- Changes in the climate/weather pattern

Life changes and perspectives

- Life satisfaction (scale of 1–5)
- Life changes (scale of 1–5)
- Hardship since the Wadi (scale of 1–5)
- Perspectives and opportunities of the next generation

Household demographics

Work/seasonal migration

Income and income sources

Memberships

Education

Assets

Consumption and nutrition

Health

Water

Ethnicity

Housing quality

*During the qualitative research phase, various topics were explored to provide context and guide the research questions. These included discussions on the environmental degradation and vulnerability nexus in general, as well as day-to-day and yearly routines of the participants, their access to markets, the supply and demand for farm products, their access to banking services, educational issues, the advantages and disadvantages of farming and rural/urban life, future generation opportunities and aspirations, impacts of infrastructure projects, farming methods, management of shared water resources, and climate change.*

# 5 Contribution 2

**Nienkerke, I., Thorat, A.,Patt, A. (2023).**

**From distress migration to selective migration: Transformative effects of agricultural development on seasonal migration.**

**World Development Perspectives. 29. 100483. 10.1016/j.wdp.2022.100483.**

## From Distress Migration to Selective Migration:

## Transformative Effects of Agricultural Development on Seasonal Migration

Mostly for survival rather than wellbeing or profit, seasonal migration is a deeply entrenched but burdensome coping strategy among the rural poor who face seasonal livelihood insecurity, trapping many in a vicious cycle of chronic poverty and seasonal migration. Can rural agricultural development programs effectively transform these livelihoods and places of seasonal migration?

Following a mixed-methods approach, including a survey of 1,860 randomly sampled households in the states of Rajasthan, Gujarat, Maharashtra, and Karnataka in India, we assess the potential of the Wadi program, which supports integrated farming systems, to boost the farmers' agricultural productivity and to change their deeply entrenched but burdensome coping strategy of seasonal migration. When comparing participants of the program with non-participants, we find a significant reduction in the intensity and frequency of seasonal migration, as well as spillover effects – that is, not only the participants but also whole villages profit from an enhanced local economy. We further analyze the general challenges and migration pattern of seasonal migrants, including the factors that play a role in the decision to seasonally migrate. We find that it is crucial to change the reasons underlying seasonal migration in order to enable the development from *distress* to *selective migration*. This study's results imply the benefits to be gained from scaling up the Wadi concept and provide evidence of its positive impacts as a contribution to the science–policy dialogue about development programs.

**Keywords:** seasonal migration, chronic poverty, rural development, mixed farming, smallholder, land use change

**Declarations of interest**: none

**Highlights**

To enable the development from *distress* to *selective migration*, it is crucial to create local alternative income sources.

Rural agricultural development can transform places of poverty and seasonal migration into income-generating settings

The intensity and frequency of seasonal migration are significantly reduced when comparing the Wadi program participants with non-participants.

Spillover effects are observed; not only the program participants but whole villages profit from an enhanced local economy.

## 1 Introduction

In 2020, for the first time, the socially invisible and politically silent floating population of Indian seasonal migrants tragically made it to the headlines of newspapers worldwide. Surprised by the COVID-19 lockdown, they were stranded and had no choice but to walk hundreds of kilometers home to their villages. Without warning, their workplaces, such as factories or construction sites, where they were living and working in hand-to-mouth, inhumane conditions, were closed, abruptly leaving them without access to money or food. Some died on the way to their distant homes (Shreehari, 2021). This tragedy finally drew public attention to the widely neglected importance of temporary migration and to the meager livelihoods of poor rural households in India, which some scholars had already noted previously (Breman, 1996; Rogaly, 1998; Haberfeld et al., 1999; de Haan, 1999; Banerjee & Duflo, 2007; Tacoli, 2009; Sucharita & Rout, 2019). It also gave momentum to the question of how to tackle the misery of leading a precarious life in a vicious cycle of chronic poverty and seasonal migration.

### 1.1 Motivation

Some economic theories treat seasonal migration as an effective coping strategy or a rational investment decision when the overall expected benefits exceed the costs involved. In this case, seasonal migration is a coping mechanism for those who cannot sustain their lives in their local

Indian vilages throughout the year; however, it is mostly for survival rather than wellbeing or profit and exacerbates the poverty trap. At their work destinations, many live in the open or in temporary shelters in unhealthy surroundings, without access to safe drinking water, sanitation, electricity, or affordable food. Structures of oppression are reproduced through labor-contracting arrangements at the destinations and may even be more exploitative than the officially forbidden caste-based oppression (Mosse et al., 2002; Olsen & Ramanamurthy, 2000). Seasonal migrants usually work on construction sites, cotton and sugarcane farms, in saltpans, stone quarries, or brick-making kilns –occupations known for low wages and harsh working conditions.

Many reports and ethnographic studies describe the status quo, but rigorous scientific assessments of potential solutions are scarce or nonexistent. This research gap motivated us to conduct our empirical study and to ask our main research question: Can rural agricultural development programs be effective enough to change the deeply entrenched but burdensome coping strategy of seasonal migration? Following a mixed-methods approach, including a survey of 1,860 randomly sampled households in Rajasthan, Gujarat, Maharashtra, and Karnataka, regions with high seasonal migration rates, we assessed the Wadi program, which supports integrated farming practices through water resource development and orchards. Foreshadowing our results, when comparing participants of the Wadi program with non-participants, we found a significant reduction in the intensity and frequency of seasonal migration, as well as evidence of spillover effects – that is, not only the participants but whole villages profited. With the lack of long-term success stories and the persistent skepticism toward supporting and funding rural agricultural projects (DIME, 2021), there is an urgent need for evidence of possible success. This study contributes to filling this gap by highlighting a way to help farmers escape from the vicious cycle of chronic poverty and seasonal migration.

### 1.2 Drivers and challenges of seasonal migration

In India, as well as other places, many smallholder farmers practice rain-fed agriculture, which is possible only for a short period of time after the monsoon season. With the farmers' inability to survive on their meager harvest and in the absence of more effective risk-management instruments, their only available coping strategy is seasonal migration. These brief migrations often occur under exploitative conditions, with the farmers returning home shortly before the next growing season and having saved next to nothing. Often, earnings from migration are used to repay debts incurred at home, as well as in the destination areas, resulting in conditions of neo-bondage (Srivastava, 2009) and further cementing the vicious cycle of chronic poverty and seasonal migration. The state of being trapped in poverty is referred to as chronic poverty (Mehta & Shah, 2003) and intergenerational poverty (Asadullah & Yalonetzky, 2012). ‘Substantial intergenerational persistence’ of poverty has been found, particularly in the cases of low-skilled and low-paying occupations, across generations in rural and urban India by comparing the socioeconomic conditions of the sons with those of their fathers (Motiram & Singh, 2012). In fact, the quest for household security often locks poor people into social structures that reduce their vulnerability but also keep them poor (Hulme, 2003).

As the most common coping livelihood strategy adopted by the rural poor to adapt to seasonal food insecurity (Sucharita & Rout, 2019), without alternatives, internal migration will persist and increase substantially (Rogaly, 1998; Mosse et al., 2005; Deshingkar & Start, 2003; Keshri & Bhagat, 2012; Nayyar & Kim, 2018). Information on the real magnitude of seasonal migration is mostly limited by the national surveys’ inability to ‘catch’ the floating population, which therefore remains statistically invisible. Estimates vary, ranging from 20% of the workforce in India (Anupama et al., 2016) to more than a quarter of the nation’s population of over one billion (Graeme, 2014; Srivastava, 2012) to 30–100 million (Deshingkar & Akter, 2009). The only established facts are that the numbers will rise and that the situation is not improving.

It appears that nothing has changed in the situation of the current seasonal migrants compared with that of past generations, when examining the literature from different decades. Selected case studies from regions overlapping with those in which our survey was carried out illustrate this point. For example, in their early case studies, Breman (1996) and Haberfeld et al. (1999) found that a large fraction of households relied on earnings from their migrant labor as a compensating mechanism for their disadvantageous position. Mosse et al. (2002) describe how long-term debt and systems of usurious money lending, labor contracting, and exploitation keep migrants in a trap where they migrate the most, work hardest, and still hardly save anything. Coffey (2013) and Roy et al. (2015) explore the difficult circumstances and educational sacrifice faced by children of seasonal migrants; these authors stress that the migrant community will remain deprived of educational opportunities and be stuck in a vicious cycle of poverty, migration, and illiteracy. In their recent case study, Visaria and Joshi (2021) report that sugarcane harvesters in Gujarat are trapped in poverty and indebtedness, living in temporary shelters under harsh conditions with the bare minimum necessities and amenities, earning less than half of the mandated minimum wage rate for agricultural laborers. Even if they were not ‘bonded,’ they had no choice, resources, skills, education, or other support to escape from going to work as sugarcane harvesters year after year and generation after generation (see also Breman, 2007, 2008). Jaleel and Chattopadhay (2021) emphasize the distress-driven nature, inhumane circumstances, and significant negative consequences on health and children. Bhattacharjee (2021) report a high likelihood of health hazards owing to the harsh working conditions and scarcity of basic amenities. Shah and Lerche (2020) focus on migrant labor, exploitation, and inequalities as crucial for capitalist growth (see also Breman, 1996). They explain how racism/casteism and the spatial politics of internal colonialism work together to the disadvantage of migrants, who are ineligible for fundamental citizenship rights and welfare measures and are treated as second-class citizens – if citizens at all. The various issues described in these selected case studies are also reported in other literature and are in line with the findings from our own experiences/research.

Seasonal migrants comprise the real engine of growth in several sectors, providing a low-cost and flexible labor source. While the economy and society reap large profits, the workers remain without identity and benefits. Employers’ and the government’s responses to protect the livelihoods of these people are almost non-existent, as they are unwilling to subsidize the costs of migration through either appropriate labor and social policies or investments in basic needs and infrastructure for migrants (Jaleel & Chattopadhay, 2021; Srivastava, 2012). Since 1979, the Interstate Migrant Workmen Act (ISMWA) has dealt with registrations of recruiters and migrant workers, licensing of contractors, details of wage rates, and journey and displacement allowances that workers should receive (Panda & Mishra, 2018). However, workers are usually unaware of their rights (Breman, 2010; Ministry of Housing and Urban Poverty Alleviation, 2017), and the government does little to nothing to implement them. Rather, the opposite is occurring, as the government is ‘reforming’ labor legislation, legalizing parts of existing illegal employment practices (Shah & Lerche, 2020). Moreover, seasonal workers have no bargaining power against corporate sector-operated industries or powerful lobbies, such as the sugar lobby, which succeeds in keeping wages low (Visaria & Joshi, 2021). In addition to the exploitation and deprivation of migrant workers’ rights, their collective action is prevented through isolation, discrimination, language barriers, debt bondage, and private security firms (Srivastava & Jha, 2016; Picherit, 2018). India’s most significant education program Sarva Shiksha Abhiyan (SSA) tries to reach out to children migrating with their families but without much success as they are simply unable to attend school or take exams when on the move, especially in Rajasthan, Gujarat, and Maharashtra (Deshingkar & Sandi, 2012) – three of the four regions covered in our study.

### 1.3 Policies to address seasonal migration and the Wadi program

The above-mentioned ineffective policies and mostly failed relief efforts usually try to treat the symptoms (i.e., the migration conditions) and neglect the causes (i.e., the underlying reasons). While improved conditions would be important and migration could be empowering, taking into account the fact that India has hit a bottleneck in the creation of new jobs in the non-farm sector or in urban areas (Agrawal, 2015), one wonders, "What could be a way out?" "Where will the good jobs come from?" (India's Economic Survey 2012–2013, Ministry of Finance, 2013). The mainstream view is that (besides the enforcement of labor laws and social protection,) solutions need to be provided in rural areas by addressing the symptoms and their underlying causes, that is, strengthening the livelihood base in these areas, creating employment and food security, and increasing the productivity of dryland agriculture (e.g., NABARD Indian Development Bank, Srivastava, 2012). Imbert and Papp (2020) suggested that a policy that would improve employment opportunities in rural areas might reduce migration from rural areas and could have large, far-reaching, spatial spillover effects. However, no rigorous scientific assessment of what could be a (permanent) solution exists so far. Anecdotal evidence is biased; while Mosse et al. (2002) did not find much success in projects promoting agriculture to curb migration, Visaria and Joshi (2021) briefly mentioned the successful cultivation of cashew nut trees in India under the Wadi program – the program that we rigorously assessed. It has been shown that this rural development program can boost income (Nienkerke et al., in press), but does it also have an impact on decreasing seasonal migration?

Wadi means 'fruit orchard' in the Gujarati language, and the core of the program lies in helping families cultivate fruit trees and intercrops. Each family is typically provided with support over four years for the establishment of a Wadi on 1 acre (0.40 ha) of the so-called wasteland, which would not otherwise be used for rain-fed crop cultivation. Since these plantations are established on degraded lands in areas prone to soil erosion and water scarcity, soil and water conservation, as well as water resource development, are essential. These measures reduce drinking water scarcity and ensure an adequate supply of water for trees and crops, especially in the summer during the growth stage. Capacity building is also included as an integral part of the program, along with the development of cooperative community organizations to better cope with challenges in the sale of the agricultural products and to ensure appropriate prices.

These activities, such as cashew processing and mango trading, create employment at the local level, also for landless people. Another crucial element is the initial financial support. Due to the relatively long gestation period of 3–5 years, during which no significant income is expected except from intercrops – provided that an irrigation facility is available – the program participants receive wages for working on their own Wadi. This enables them to take care of their Wadi, instead of opting for distress seasonal migration (for more details on the Wadi program, refer to Nienkerke & Patt, 2022).

## 2 Materials and Methods

### 2.1 Control, intermediate, and treatment groups

The way that the Wadi program was implemented and its rules for selecting participants automatically produced a natural experiment. It was implemented in a randomized rollout; more precisely, the program was gradually phased in geographically since the early 1990s, incorporating all interested beneficiaries in one village or region before moving to the next. It was introduced through village and hamlet meetings and exposure visits, and all households were given an equal opportunity to participate. This allowed a randomized evaluation design that would avoid selection bias, would provide good internal validity, and could rely on weaker assumptions compared with those of other methods (Gertler et al., 2016). Villages in the program area had the opportunity to join the program within a certain year, while villages outside of this area had to wait for their turn. Therefore, the villages and households that were located just outside the program area –and thus had no opportunity to participate at that time – served as control villages.

To assess not only the households but also the transformation/development of *places* (i.e., villages and hamlets) and possible spillover effects, we examined two different groups in the treatment villages – randomly sampled participating households *and* randomly sampled non-participating households – and compared those with places of persistent seasonal migration (i.e., control villages). The non-participants in program villages thus formed an intermediary group between the pure control and the pure treatment groups. If they would profit from the program, this would show that it generated spillover benefits, going beyond the group of participants. Figure 1 visualizes the research design:

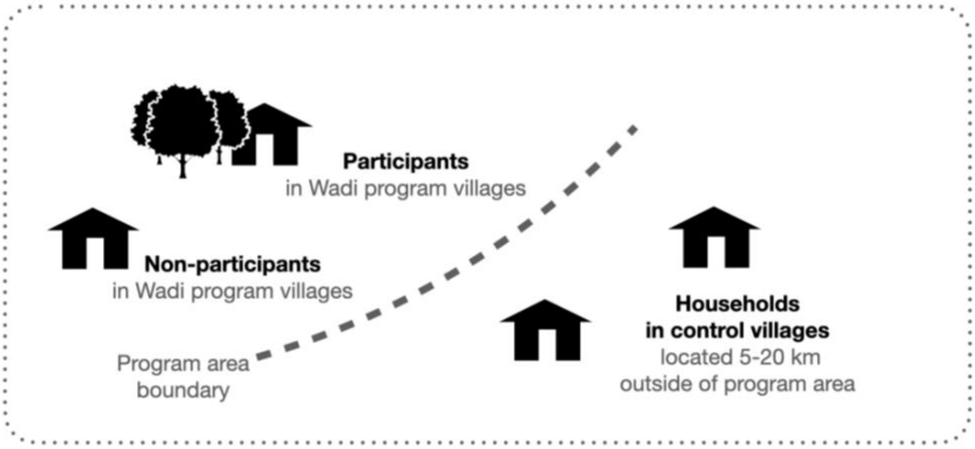


Figure 1: Visualization of the research design

**Notes:**

*Participants:* Randomly sampled participating households.

*Non-participants in Wadi program villages:* Randomly sampled households that did not participate in the program when it was rolled out in their village. Intermediary group between pure control and pure treatment groups to analyze spillover effects.

*Households in control villages:* Randomly sampled households in villages 5–20 km outside of the program areas, thus not having the opportunity to participate yet. The control villages were carefully selected in consultation with local experts and based on a list of criteria in order to match the program villages with regard to external factors.

### 2.2 Mixed methods

We followed a mixed-methods approach that started with qualitative evidence gathering, moved to quantitative evidence to be able to ascertain significant findings, and finished with additional qualitative evidence to deepen our understanding of the processes at work. The first step was *participatory rural appraisal,* including field visits, focus group discussions, and qualitative interviews with the participants, as well as non-participants, NGOs, local and international experts, ministers, teachers, health professionals, Indian Development Bank professionals, tribal institutes, and development agencies. Based on this, a *quantitative survey* was developed and conducted face-to-face in the four Indian states of Rajasthan, Maharashtra, Gujarat, and Karnataka, representing different geographic regions. Figure 2 shows a map of the research areas. In addition to the main questions on several indicators, a set of questions addressed to the interviewer about how well the respondents understood the questions, a section on the geographical context, as well as an open question for remarks and collection of GPS data, provided validity and reliability checks and additional insights. After the survey, the interviewers in each state discussed and reported their personal experiences, impressions, challenges, and solutions. Throughout the research process, qualitative interviews with stakeholders or local experts were conducted whenever needed for verification or clarification.

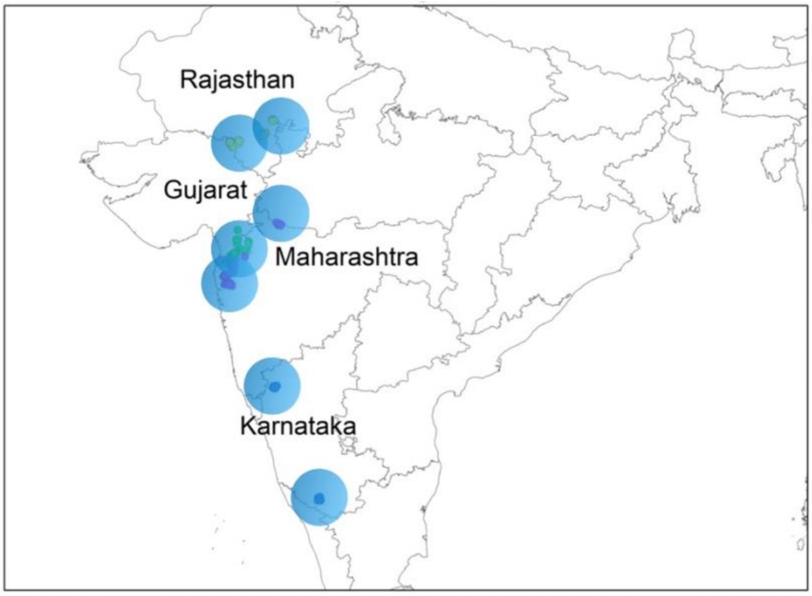


Figure 2: Map of India, indicating the research areas

### 2.3 Survey design and sampling

The survey was conducted with 1,860 randomly sampled households (1,132 participating households and 728 non-participating households). Detailed information was gathered from all members of the households, thus enabling analyses at both individual and household levels. The sample was randomly drawn from the population of all households that participated in the program in the four states, totaling 188,231. As a backup, an additional short list of randomly sampled households had been prepared for the rare cases in which the residents of a sampled household were nowhere to be found on two visits by the interviewer or did not give their consent to be interviewed. The questionnaire for this quantitative survey was rigorously tested in the field and translated in an iterative process. The interviewers were experienced and trained, knew the local context and dialect, and used ODK software (Hartung et al., 2010) on their smartphones. This direct digital input of data and mostly (closed) multiple-choice questions kept possible errors and data cleaning to a minimum.

In our analysis, we compared the three groups with respect to various parameters and conducted stepwise linear regressions.

## 3 Results

Our analysis considers three questions in sequence. First, can we gain deeper insights into the general challenges and migration pattern of seasonal migrants, including the factors that play a role in their decision to seasonally migrate? Second, can a rural agricultural development program – in this case, the Wadi program, reduce the intensity (months per year) and frequency (times per year) of seasonal migration? Third and finally, are there possible spillover effects? In particular, we evaluate the possibility of spillovers by examining non-participating households in program villages, which form an intermediary group in between our pure control and pure treatment groups.

### 3.1 Descriptive statistics of all households

The descriptive statistics table (Table 1) contains the key similarities and differences among the three groups. We find that almost all surveyed households prefer farming to seasonal migration for the same income. The groups are also very similar regarding age, remoteness, landholding, household size, and gender ratio. However, they have substantial differences in wealth, debt, number of income sources, area of cultivated and irrigated land, income from farming, and water availability. More households of the treatment group report having a kitchen garden and having always enough to eat when staying home, as well as during their seasonal migration. Members of the treatment group under 18 years old, on average, have completed one more year of education compared with the control group's members.

Table 4: Descriptive statistics of all surveyed households per group [1]

| | Households in CONTROL Group | Non-participating households in program villages | Households in TREATMENT group |
|---|---|---|---|
| **Variables with similar values in all groups** | | | |
| Preferring farming to migration for the same income (% of people) | 94 | 89 | 96 |
| Age (household average) | 29 | 26 | 29 |
| Familysize / number of people in household | 5.9 | 4.9 | 5.3 |
| Gender ratio (f/m) | 48/52 | 50/50 | 48/52 |
| Travel time to primary school in minutes | 13 | 13 | 14 |
| Travel time to secondary school in minutes | 36 | 34 | 36 |
| Walking distance to the nearest drinking water source in minutes | 17 | 12 | 15 |
| Own landholding in acres | 2.8 | 2.5 | 3.2 |
| | | | |
| **Variables with different values in all groups** | | | |
| Ever left for seasonal migration (% of people) | 31 | 22 | 13 |
| Seasonally migrated last year (% of people) | 16 | 12 | 7 |
| Seasonal migration: times per year (household average) | 3 | 2 | 1 |
| Seasonal migration: months per year (household average) | 2.4 | 1.8 | 1 |
| Seasonal migration: furthest destination (household average) | 76 | 50 | 41 |
| Seasonal migration: net income per household per year | 19,000 | 10,000 | 10,000 |
| Enough to eat during seasonal migration or not migrating (% of people) | 52 | 77 | 85 |
| Always enough to eat when staying at home (% of people) | 56 | 72 | 85 |
| Number of children who join IF the family seasonally migrates | 1.4 | 1.1 | 1 |
| Educational years completed under age of 18 (household average) | 4.6 | 5 | 5.7 |
| Years of education desired for girls | 12 | 12 | 13 |
| Number of income sources per household | 6 | 6 | 8 |
| Wealth in Rupees (including debt and savings) | 34,000 | 33,000 | 65,000 |
| Debt in Rupees | 10,000 | 3,700 | 3,800 |
| Farming income in Rupees per household per year | 18,000 | 18,000 | 50,000 |
| Irrigated land in acres | 0.4 | 0.8 | 1.3 |
| Cultivated land in acres | 2.4 | 2.5 | 3.1 |
| Cultivating kitchen garden, i.e. improved dietary diversity (% of households) | 16 | 21 | 50 |
| Adequate water availability (% of households) | 67 | 85 | 91 |

[1] The exchange rate for Indian Rupees was: INR 80 for one Euro on 1. March 2018

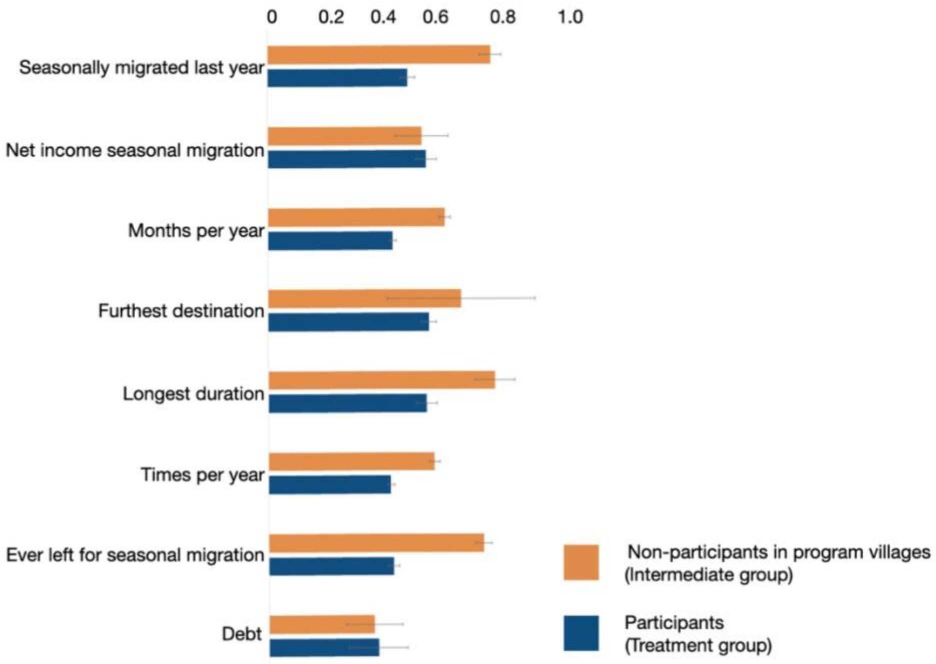


Figure 3: Migration parameters, household averages. Ratio of average parameter values for the intermediate and treatment groups to those of the control group.

Figure 3 shows that the households of the treatment group, on average, have lower values for all migration parameters, namely how many people migrated in the year preceding the survey, income from seasonal migration, months per year (intensity), farthest destination, longest duration, times per year (frequency), how many members of a household ever seasonally migrated, and debt. Debt is not necessarily but very likely linked to seasonal migration and therefore included in this figure (see section 1.2 Drivers and challenges of seasonal migration, for details on the debt trap of seasonal migrants).

### 3.2 Seasonal migrants, quantitative results

Next, we turn from the household level to focus on the people who seasonally migrated in the year preceding the survey. The descriptive statistics in Table 2 and Figure 4 show that all migration parameter values of the treatment group are slightly lower than those of the control group, except income from seasonal migration, which is much higher for seasonal migrants in the treatment group than for those in the control group. The former group also shows higher/better values in educational matters and a preference for rural over urban destinations.

Table 5: Descriptive statistics of people who migrated last year

| | Migrants in CONTROL Group | Non-participating people in program villages, who migrate | Migrants in TREATMENT Group |
|---|---|---|---|
| **Variables with similar values in all groups** | | | |
| Age (household average) | 35 | 33 | 35 |
| Gender ratio (f/m) | 23/77 | 23/77 | 22/78 |
| Seasonal migration within same state (vs.to other state) | 80 | 89 | 80 |
| Seasonal migration: times per year (household average) | 4 | 3.9 | 3.6 |
| Seasonal migration: months per year (household average) | 3.6 | 3.4 | 3.1 |
| | | | |
| **Variables with different values in all groups** | | | |
| Number of income sources per household | 7 | 6 | 10 |
| Own landholding in acres | 2 | 2.2 | 3 |
| Familysize / number of people in household | 6 | 5 | 7 |
| Wealth in Rupees (including debt and savings) | 56,000 | 38,000 | 99,000 |
| Educational years completed under age of 18 (household average) | 4 | 9 | 7 |
| Ever attended school (% of people) | 75 | 44 | 84 |
| Currently enrolled in school (% of people) | 0 | 0 | 38 |
| Seasonally migrating to rural/urban destination (% of people) | 40/53 | 46/52 | 56/42 |
| Seasonal migration: net income per household per year | 15,000 | 14,000 | 19,000 |

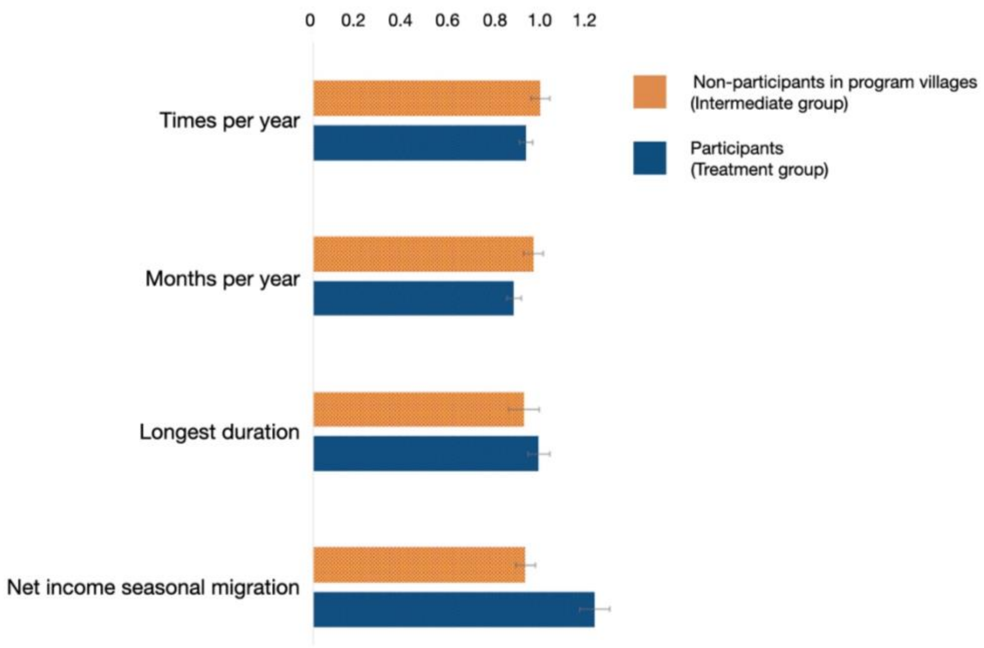


Figure 4: Migration parameters of people who seasonally migrated last year. Ratio of average parameter values for the intermediate and treatment groups to those of the control group.

### 3.3 Seasonal migrants, qualitative results

In the focus group discussions with women from the villages in our research area, as well as in the qualitative interviews, seasonal migration and the typical pattern and challenges were thematized/addressed. The key aspects were similar across the families from the villages in the control group, as well as the families that became program participants but reported about their lives as seasonal migrants previously. Figure 5 represents a typical example of the yearly migration pattern, in this case, a couple from Maharashtra. Each year, they leave their village in mid-January to work in construction in Thane, where he earns 250 rupees (Rs) per day and she earns 200 Rs per day (2–3 euros). In all labor arrangements, it is common for women to earn less than men. Sometimes, they return home for a couple of days to celebrate the Holi festival, but in any case, they return home by the end of May for the monsoon season, which is from June to September. They plant and harvest rain-fed crops such as rice and millet for subsistence and stay until after the important Diwali festival, which – depending on the year – is held around the end of October/mid-November. By then, they run out of resources and leave to work as agricultural laborers until December at least. Depending on the year and the situation, they find more work or return home until the whole seasonal migration begins anew.

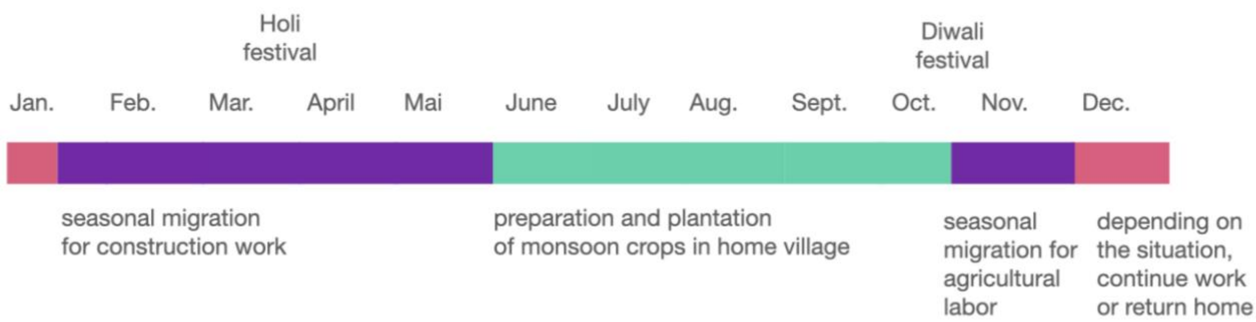


Figure 5: Yearly migration pattern of a typical poor smallholder family from Maharashtra

Typically, seasonal migrants take food, all cooking resources and fuel, wood, or kerosene along when they depart in search of labor. When they run out of these items, a family member goes back and gets resources again. They explain that food at the destination is too expensive and only in their home village can they buy subsidized rice with their ration card. Depending on the distance between their home village and possible work sites, they stay from a week to several months at the work location, and when they return to the village, they leave after a couple of days again. Many stay home for four months for monsoon crops; others *"only go home when there is a festival."* The seasonal migrants all confirm that they do not migrate out of choice but out of distress because there is *"no livelihood in the village (...); after harvesting (of* *monsoon crops), there is nothing to do other than migrating."* They say that the jobs vary but all are hard, low-skilled, and low-paying, such as cultivating onions, cutting grass, building dams, working in concrete construction, or carrying 15-kg headloads of sand or rice to load trucks. *"Without doing hard work, we cannot fill our empty stomachs."* We also conducted interviews in the workplaces of seasonal migrants, as well as in the meeting places of seasonal migrants and people looking for workers. Most seasonal migrants arrive in groups, some with the whole family, including the elderly and children, carrying foodstuff and firewood. Usually, the groups select one person to negotiate with potential employers. In all cases, the wage earned is low, but what is eventually kept is even lower. To cite an example, *"Even if we get 3,000 Rs, we cannot take home the full amount; 1,000 Rs is expended on fare, then 500 Rs for home expenses, 100 Rs for this (and that), and 500 Rs in the bank."* While the seasonal migrants talk about the exhausting work and poor conditions, the employers usually speak highly of the workers: *"I am confident that this work can be done skillfully only by these people because of the way that God has created them; their body structure, energy levels, stamina, and persistence are well suited to the job."* Another employer is enthusiastic about the extraordinary amenities that he provides to the agricultural laborers because they can sleep in a garage, which *even* has a light bulb.

The main three challenges associated with seasonal migration are (1) health and accommodations *"because we have no money, we stay without shelter,"* (2) food – *"many times, we go hungry to work,"* and (3) taking care of children, who *"also work in the fields"* or *"stay with grandparents, but when they are too old or unable to take care of them, they have to come along, and this results in discontinuation of education,"* or *"they are home alone, so [there is] no one to pay attention if they go to school, take a bath or not."* Besides the impossibility to attend school when on the move, the migrant workers' financial situation is stated as the main reason for school dropouts, as well as their lack of family support, lack of self-confidence, lack of an adequate learning environment, and discrimination. *"For a village person, receiving education is similar to milking a lion; we have to deal with so many situations and hardships."* We find anecdotal evidence that when children stay home with their grandparents or other relatives, they also often do not attend school because their grandparents do not regard school as important and there are many other tasks to do. Sometimes, there is the option of a residential boarding school (Ashram school). This is a topic of its own, and we sum it up by daring to ask, "Who likes to send one's young children to a not particularly child-friendly institution for up to eight months per year when the educational outcome is unclear?"

Program participants report that they previously migrated *"to make both ends meet,"* but they can now stay home, *"take some rest, and earn good income from our land itself, instead of going to do labor work." "We cultivate something or another all year round."* In many villages, none of the Wadi holders migrate anymore, whereas previously, almost the entire village left. For example, in a village with 336 residents, over 300 used to migrate. They explain, *"Now, there is stability in life"*; they can take care of their children the whole time and send them to school regularly. They have also increased their dietary diversity: *"Now we have vegetables in our diet because we grow them in our farm. In the past, we used to eat them only when we got them, but now, they're always available."*

Many people who did not participate in the Wadi program at that time (e.g., because of their skepticism) have later realized its importance and established Wadis at their own expense. *"People have realized that even if they have (only) 10 mango trees and if they have proper fruiting for 4 months, then they can survive on this income for 4 months."* Others planted an additional Wadi: *"Obviously, we took up a new Wadi because we got benefits from the existing one."* Wadi owners also report that unseasonal rainfalls have caused damage to rice and wheat, while trees have been unaffected.

### 3.4 Factors influencing the decision to seasonally migrate

What factors influence someone to stay or leave home for seasonal migration? In a stepwise linear regression analysis, we scrutinize which factors play a role in the (1) intensity (months per year) and (2) frequency (times per year) of seasonal migration. We find all factors significant and the adjusted R-squared values to be 0.52 in (1) and 0.44 in (2). The overall models are significant, with $F(12, 833) = 78.70$ and $p < .001$ for (1) and $F(12, 833) = 53.92$ and $p < .001$ for (2). Debt, remoteness, and household size (number of family members) increase seasonal migration, while farming income, area of irrigated land, number of fruit trees, number of years of education of the person with the highest education in the household, average age in the household, and average years of education per household have negative impacts.

Table 6: Stepwise linear regression models of factors influencing seasonal migration (1) frequency (times/year) and (2) intensity (months/year) of seasonal migrants.

| | *Dependent variable:* | |
|---|---|---|
| | Times/year | Months/year |
| | (1) | (2) |
| Max.of educational years completed | $-0.200^{***}$ | $-0.156^{***}$ |
| | (0.047) | (0.038) |
| Irrigated land | $-0.496^{**}$ | $-0.876^{***}$ |
| | (0.221) | (0.178) |
| Farming income | $-0.0001^{***}$ | $-0.0001^{***}$ |
| | (0.00001) | (0.00001) |
| Debt | $0.00003^{***}$ | $0.00003^{***}$ |
| | (0.00001) | (0.00001) |
| Age | $-0.055^{***}$ | $-0.038^{***}$ |
| | (0.015) | (0.012) |
| Own landholding | $-0.349^{***}$ | $-0.209^{**}$ |
| | (0.127) | (0.102) |
| Education | $-0.173^{***}$ | $-0.119^{***}$ |
| | (0.045) | (0.036) |
| Proxy for remoteness | $0.037^{**}$ | $0.046^{***}$ |
| | (0.016) | (0.013) |
| Householdsize | $0.579^{***}$ | $0.486^{***}$ |
| | (0.080) | (0.064) |
| No. of fruit trees | $-0.016^{**}$ | $-0.023^{***}$ |
| | (0.007) | (0.006) |
| Wealth | $0.0001^{***}$ | $0.0001^{***}$ |
| | (0.00000) | (0.00000) |
| Constant | $6.759^{***}$ | $4.999^{***}$ |
| | (0.887) | (0.713) |
| Observations | 846 | 846 |
| $R^2$ | 0.437 | 0.531 |
| Adjusted $R^2$ | 0.429 | 0.525 |
| Residual Std. Error (df = 833) | 4.945 | 3.974 |
| F Statistic (df = 12; 833) | $53.925^{***}$ | $78.704^{***}$ |
| *Note:* | $^{*}$p<0.1; $^{**}$p<0.05; $^{***}$p<0.01 | |

If farming income increases by 10,000 rs, this leads to 1 month less of migration per year. An increase of 1 acre of irrigated land results in 0.88 month less, while an increase in landholding by 1 acre results only in 0.2 month less. Education has an impact, as 1 more year of the average education level per household reduces migration by 0.12 month and 1 more year of education for the best-educated person in the household by 0.16 month less. One more person in the household leads to 0.49 month more of migration; if debt increases by 10,000 rs, the number of months spent migrating increases by 0.3. Remoteness, measured in travel time to primary school, increases migration months by 0.46 for every 10 minutes more of travel time.

In the variable comparison (Figure 6), the beta coefficients show that the variables *farming income* and *family size* cause the largest changes in the number of months of seasonal migration per year.

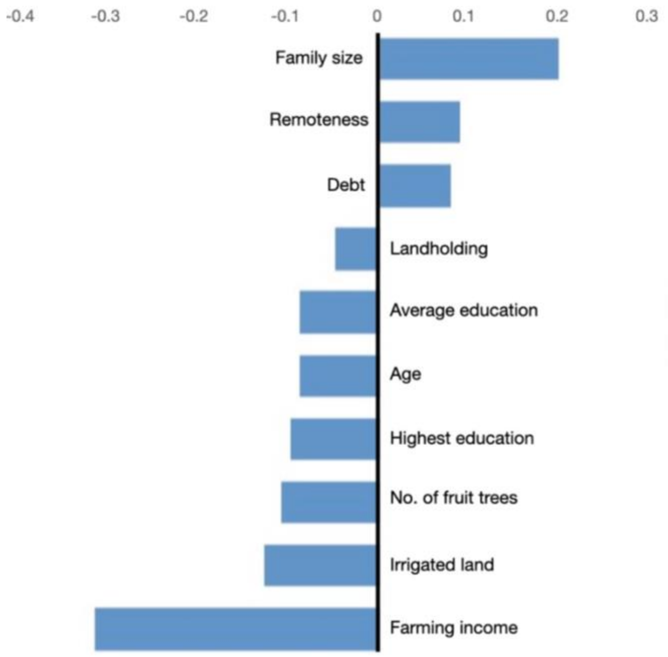


Figure 6: Factors found to be significant in the regression model (2) Months/year

Income from farming, area of irrigated land, and number of (fruit) trees are also correlated with many rural development efforts, so these results might indicate that programs such as the Wadi have the potential to reduce seasonal migration. We scrutinize this hypothesis in the following subsection.

### 3.5 Program impact on seasonal migration

Table 4: Impact of program participation (Treatment, i.e. participants in program villages) and program spillover effects (Intermediate group, i.e. non-participants in program villages) on frequency (times/year) and intensity (months/year) of seasonal migration.

| | *Dependent variable:* | |
|---|---|---|
| | Times/year (1) | Months/year (2) |
| Participants | -3.795*** | -3.185*** |
| | (0.169) | (0.145) |
| Non-participants in program villages | -2.017*** | -1.454*** |
| | (0.192) | (0.165) |
| Proxy for remoteness | 0.039*** | 0.031*** |
| | (0.002) | (0.002) |
| Own landholding | -0.296*** | -0.225*** |
| | (0.027) | (0.023) |
| Householdsize | 0.576*** | 0.501*** |
| | (0.023) | (0.019) |
| Wealth | 0.00002*** | 0.00002*** |
| | (0.00000) | (0.00000) |
| Gender = male | 0.233** | 0.161* |
| | (0.097) | (0.083) |
| Education | -0.053*** | -0.042*** |
| | (0.011) | (0.010) |
| Age | 0.005* | 0.006*** |
| | (0.003) | (0.002) |
| Constant | 0.919*** | 0.521** |
| | (0.264) | (0.226) |
| Observations | 9,346 | 9,346 |
| $R^2$ | 0.229 | 0.234 |
| Adjusted $R^2$ | 0.228 | 0.234 |
| Residual Std. Error (df = 9336) | 4.607 | 3.951 |
| F Statistic (df = 9; 9336) | 307.495*** | 317.337*** |
| *Note:* | *p<0.1; **p<0.05; ***p<0.01 | |

The multiple linear regression analysis shows a significant impact of program participation on the reduction of seasonal migration in both frequency (1) and intensity (2). The overall models are significant, with $F$ (9, 9336) = 307.5 and $p < .001$ for (1) and $F$ (9, 9336) = 317.34 and $p <$ .001for (2). The members of participating households leave home $b$ = -3.795 ($p < .001$) times less for seasonal migration per year and are gone for seasonal migration $b$ = -3.815 ($p < .001$) months less per year than the members of the households in the villages belonging to the control group. Household size and being male also have significant positive impacts on the intensity and frequency of seasonal migration, while larger landholdings result in less migration. Spillover effects are evident; even the non-participants in the villages covered by the program undertake significantly less seasonal migration: *b* = -2.017 ($p < .001$) times less and *b* = -1.454 ($p < .001$) months less than the households in the control group.

Furthermore, over 60% of participating households report having *at least one* person (who used to migrate seasonally) staying home since treatment (i.e. joining the program). Of the participating households where someone is still migrating, 79% report *at least one* person (who used to migrate seasonally) staying home since treatment. Seasonal migration also has a negative impact on life satisfaction (*b* = -.136, $p < .001$), measured on a 5-point Likert scale. The spillover effect also becomes visible through the Wadi development of the non-participants without external support in the villages covered by the program (*b* = -.262, $p < .001$). This is also reflected in Figure 7; the non-participants in the villages covered by the program generate a larger share of their income from farming than from seasonal migration compared with the control group.

### 3.6 Distribution of income sources per group

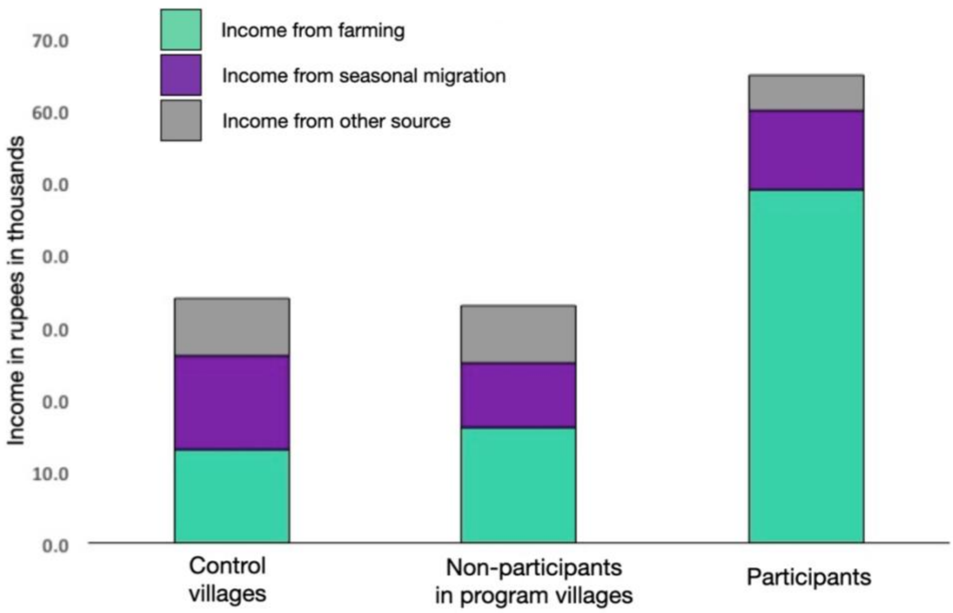


Figure 7: Comparison of main income sources per household and groups: income from seasonal migration, income from farming and income from other source (bottom to top).

The households in the treatment group earn more income overall, but the ratio/distribution of their income sources also differs from those of the other groups. While the households in the treatment group generate most of their income from farming, the households in the control group depend highly on seasonal migration. The non-participants in the villages covered by the program earn a total income similar to that of the control group but undertake less seasonal migration and more farming.

## 4. Discussion

Can a rural development program enable marginalized, smallholder farmers in India to break away from a vicious cycle of chronic poverty and seasonal migration? The answer is yes. Previously, the families were forced to leave their villages every season, after the harvest of the *kharif* (summer/monsoon) crop, in search of labor. The program constitutes a fundamental change to their lives. Frequency (months per year) as well as intensity (times per year), duration per stay, distance to the destination, percentage of the people who migrated seasonally, and debt have been significantly reduced. Now, the participating farmers have an assured source of income from their Wadis and can stay in their villages throughout the year, while the farmers in the villages belonging to the control group still depend primarily on seasonal migration and rain-fed agriculture after the monsoon season, only returning occasionally to celebrate important festivities or to pick up foodstuff. It is clear that festivals and the associated care of social networks play a dominant role in the migration pattern, as seasonal migrants invest scarce resources in returning home to participate in such events. Farmers are attached to their home villages, even though these places cannot sustain their lives throughout the year. Given their overall low economic status, which they do not manage to improve with seasonal migration either, they take the opportunity to grow some rain-fed crops on their small landholdings in order to contribute to their subsistence.

Generally and globally, migration and development studies view temporary internal labor migration with optimism, as it can contribute to poverty reduction and human development in low resource settings (e.g., Dodd et al., 2016). However, this is mostly not the case in India, where local realities include the presence of exploitative labor arrangements, a domestic policy environment that largely neglects migrant workers and their rights, and distress-induced migration trajectories where labor migration represents a necessity for household subsistence rather than a free choice (Deshingkar & Akter, 2009; Deshingkar & Start, 2003; Mosse et al., 2005; Rogaly et al., 2001). From the perspective of employers in need of unskilled labor, seasonal migrants comprise the perfect workforce. They are unskilled and can therefore be paid low wages, in desperate need of money and thus hardworking, and can be treated as if they do not have any rights and without consequences.

Seasonal migration is a complex phenomenon. The question of which factors influence the migration pattern and 'who migrates' has no simple answer as many factors play a role. We find that the household characteristics of the migrant decision maker, especially in the context of increasing agricultural returns, such as irrigation and the number of fruit trees, as well as income from farming itself, are more important than individual characteristics. Enhancing these factors in order to boost agricultural productivity and income is usually the objective of rural development programs.

In the Wadi program, its participants' ongoing presence has dramatically changed their relationship to their land. They now invest in further agricultural improvements, diversify their crops, expand their Wadis, or take up additional income-generating activities. Contrary to the control group, they improve their dietary diversity with their kitchen gardens and confirm that they always have enough to eat at home. The barren wastelands have been transformed into lush green hills with fruit and forestry trees and intercrops. Many farmers have constructed huts in their orchards or moved there completely from the village. Some speak of a reversal of migration for nature conservation. Their ability to stay home has a positive impact on education. All of the participating families surveyed emphasize that their children attend school and that they invest a significant portion of their income in their children's education and other associated costs. Higher education has been found only among the participants. In contrast, the members of the control group mention seasonal migration and costs as reasons for school dropouts. The migration of either one or both parents has the potential of reducing the child's probability of attending school, and an out-of-school child is an important indicator of child labor (Srivastava, 2012). According to Coffey (2013), the most critical social cost borne by seasonal migrants is their inability to send their children to school.

We have learned that almost all surveyed households prefer farming to seasonal migration for the same income. This widespread aversion to seasonal migration is not surprising in the face of the described harsh and exploitative circumstances and is further reflected in the negative impact of seasonal migration on life satisfaction. It is therefore encouraging to find that in over

60% of the participating households, at least one person has permanently stopped migrating seasonally since joining the program. Any seasonal migration that still occurs among the participants is not needed for survival but a chance for one member of the family to generate additional income from elsewhere, at certain times of the year when agricultural activities require less manpower. Thus, we find a development from *distress* to *selective migration*. Participating households do not just stop migrating but on average, migrate less than half as much as the control group, while interestingly, their income from seasonal migration is more than half of the earnings of those who migrate for survival. For a seasonal migrant from a participating family, this means earning more money in the same period of time. This is because they can afford to pick only the better offers and are spared the agony of distress migration. They do not have to work at all in the jobs that can be considered the harshest – brick kiln and stone quarry – and less in construction and industrial work in general. However, they are overrepresented in more attractive, skilled, and better-paid jobs, such as tailoring or government service. They also mostly prefer to take jobs in nearby rural areas.

With these findings in mind, we address the important (but as of now, widely left unanswered) question (already posed by Haberfeld et al., 1999) of whether social policies should aim at reducing seasonal migration. We emphasize that the crucial point is to *change the underlying reason* (i.e., chronic poverty) of distress-induced seasonal migration. For many migrant workers, seasonal migration is a defensive coping strategy, which persists even though the families do not improve their income or security but perpetuate their dependency by only servicing high-interest, subsistence-related debts. Here, it makes an essential difference to create alternative income sources at home in order to enable the transition from distress to selective migration. As a result, a few will still leave home for seasonal migration out of choice to further diversify their stable rural existence and to invest in assets, but they no longer depend on the most crucial practices and can pick the better offers. This goes hand in hand with the finding that people under the age of 18 who seasonally migrate and whose families are program participants have completed, on average, 7 years of education compared with 4 years in the control group. Seasonal migration cannot be stopped (Sucharita & Rout, 2019), and it should not be the goal of development efforts to prevent it entirely. It is a by-product of developmental processes, important for the redistribution of resources from richer to poorer localities, and stopping it would mean depriving people of jobs and experiences outside their villages. Thus, opposing migration and rural livelihoods is false, just as the case of simply taking the reduction of seasonal migration as the measurement of the success of rural development (de Haan, 1999).

One has to move beyond a narrow economistic viewpoint and acknowledge seasonal migration as part of diverse livelihood strategies.

Our findings suggest important spillover effects, namely that entire places of seasonal migration can be transformed. There is a significant positive impact on the village level as non-participants also profit from an enhanced local economy. They now find employment opportunities nearby, such as agricultural labor in Wadis, processing, or marketing of Wadi produce (e.g., cashew and mango). Compared with the control group, their dependence on seasonal migration is substantially less in all parameters: frequency, intensity, duration, distance, income, and debt. Another positive spillover effect is the widespread development of Wadis without external support.

This impact assessment provides better insights into the underlying causal links, generating an understanding that can feed into the design of future programs. The Wadi concept can be scaled up to reduce distress migration elsewhere, too, as this type of migration is common in developing countries (Banerjee & Duflo, 2007; Bryan et al., 2014; Morten, 2016). The Wadi program has drastically improved the lives of poor smallholders, enabling them to escape a vicious cycle of poverty and seasonal migration. The smallholders have converted wastelands into valuable assets and are now literally rooted to their lands, just like the trees they planted.

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# 6 Contribution 3

**Nienkerke, I., & Patt, A. (2022).**

**From wasteland to oasis: Transformative effects of trees on farmland and livelihoods.**

**Land Degradation & Development, 33(18), 3773–3785.**

**https://doi.org/10.1002/ldr.4422**

## From wasteland to oasis:

## Transformative effects of trees on farmland and livelihoods

In face of today's alarming trend of resource degradation and reversal of poverty reduction, path-breaking strategies are needed. However, there is limited evidence to inform the design of policies. We scrutinized an agricultural development program that follows a holistic approach and includes the cultivation of fruit trees, to tackle this natural resource degradation and human vulnerability nexus. Can it transform so-called wastelands and lift marginalized smallholders out of poverty? The geographic rollout of the program produced a natural experiment that allowed for an evaluation design with treatment and control groups and a survey of 2000 households randomly sampled from 188,231 participants in four Indian states, covering geographically diverse areas. This is the first time that the livelihood impacts of such farming systems have been analyzed on such a large scale and over a 23-year period. Our results show that degraded farmland can be transformed into green assets if poverty alleviation and environmental regeneration are tackled in a holistic manner. We find a clear and significant trend in the improvement of socio-economic factors, including higher income and positive life changes, as well as ecological benefits. By assessing the potential of trees to reverse environmental degradation and alleviate chronic poverty, this study provides much- needed evidence for the science-policy dialog of development programs. This video (3 minutes) gives an impression of the context of the study (Video S1).

**Keywords**: fruit trees, integrated farming system, land degradation, poverty, smallholders, sustainable intensification

# 1 Introduction

In many places worldwide, smallholder farmers are living in marginalized rural areas, struggling to make a living. More than 3 billion people depend directly on soil and land (FAO, 2017), increasingly degraded natural resources (IFAD, 2015; World Bank, 2018), as one-third of all land and 20 percent of all forest cover have already been severely degraded (UNCCD, 2017). In India, rapid depletion of forest resources over the last 8–10 decades has severely affected food security for the most deeply impoverished of the population, those who were dependent on various forest products for their livelihoods. The most affected people belong to indigenous tribal groups (Adivasis) and are often set apart geographically and socially from the rest of India. Most of the families own just 0.5– 1 ha of land, which is used to grow a few food crops such as paddy, millets and pulses, mostly without any inputs and technologies and yielding barely enough output to meet the needs of the family. Unable to ensure their livelihood with the meager harvests of rainfed subsistence agriculture alone, they migrate seasonally with their families in search of wages for 6–8 months every year, often under exploitative conditions. These smallholders are stuck in poverty despite aggressive affirmative action policies by the Government of India and despite substantial improvements in incomes among all Indians (Thorat et al., 2017).

There are several factors that contribute to this seemingly hopeless situation. The farmlands of the marginalized smallholders can be categorized as highly degraded crop lands, having very little topsoil and organic carbon. Deforestation and rampant shifting cultivation practice cause extensive soil erosion, as, without vegetation, fertile topsoil is washed away in frequent bouts of heavy rainfall. This further reduces the capacity of water to trickle into the ground to recharge aquifers and leads to water scarcity. The land turns into a so-called 'wasteland.' This, along with a shortage of capital or alternative employment opportunities, indebtedness, financial illiteracy, lack of knowledge on improved agricultural practices, lack of diversification and poor educational levels, cements the low level of development across generations (Asadullah & Yalonetzky, 2012; Mehta & Shah, 2003).

## 1.1 Motivation

Poverty alleviation, rural agricultural development, as well as combatting environmental degradation have always been great challenges. Moreover, water scarcity and loss of fertile soil are expected to further deteriorate in the face of climate change, along with rural livelihoods, which depend on these natural resources. The IPCC (2019) expects climate change to worsen land degradation and food insecurity with high confidence, that it will exacerbate the vulnerability-related risks of resource-dependent communities, further strain their adaptive capacity and increase their susceptibility and exposure to climate shocks (Lange et al., 2018; World Bank, 2010). The combined forces of resource degradation and climate change could force more than 100 million people into poverty by 2030, especially in Africa and South Asia (World Bank, 2016), severely affecting food security (Scholes et al., 2018), and contribute to the displacement of 143 million people, many of whom are vulnerable and live in degraded areas (Rigaud et al., 2018).

There are many projects attempting to halt soil erosion and environmental degradation, such as afforestation projects, which also claim to mitigate climate change through carbon sequestration. However, many fail because they do not include the people -or even worse, increase the vulnerability of the impoverished. "Land management practices that seek to restore degraded land can run the risk of exacerbating vulnerability, possibly causing harm..." (Independent Evaluation Group, 2021). For the remaining –possibly successful projects, the effectiveness can be questioned. With only a few long-term success stories and persistent skepticism towards supporting and funding rural agricultural projects, there is an urgent need for evidence of possible success. As DIME (2021) states, "...Sustainable Development Goals urge the international community to make the investments needed to double agricultural incomes of small-scale food producers. However, current yield trends suggest a need for path-breaking innovations to come to the rain-fed areas of the world to meet this target. Astonishingly little evidence exists to rigorously inform the investments needed to meet this urgent goal."

One potential bright spot in this context may be the wadi program, which has a strong focus on trees and people. Initiated in the early 1980s, it has since been rolled out over various Indian states, including regions characterized by degraded wastelands. There are reasons to believe that the wadi Program may offer insights for future development projects, which will be elaborated on in the following sections. Following a mixed methods approach, including a survey of 1860 randomly sampled households in Rajasthan, Gujarat, Maharashtra and Karnataka, we tackled the research question of whether fruit trees can transform wastelands and lift marginalized smallholders out of poverty. To foreshadow our results, we found a significant improvement across multiple indicators: economic benefits, positive life changes and social benefits, environment and climate resilience, as well as village life and the local economy. By assessing the potential of fruit trees to revert environmental degradation and alleviate chronic poverty, this study provides much-needed evidence in the science-policy dialog of development programs.

### 1.2 Opportunities and challenges of greening efforts

The natural resources that are highly degraded and the people, who are highly vulnerable, are interconnected by the "natural resource degradation and human vulnerability nexus". However, the highly appealing vision that practices of resource recovery will automatically lead to increases in social resilience is far from the truth. Too often, afforestation projects or 'green' projects in general, fail to involve the people and run the risk of exacerbating the vulnerability of poor resource users. Greening efforts in countries all around the world have brought to light how local poverty can either be increased or reduced. These efforts may improve the livelihoods of some house- holds while hurting others (Coleman et al., 2021; Ramprasad et al., 2020; Rozelle et al., 2000). The World Bank evaluated its own projects that apply natural resource management practices, concluding that they struggle to find the right balance between achieving resource recovery and meeting the welfare needs of vulnerable resource users because The World Bank does not adequately address the resource-related vulnerability of resource-dependent people (Independent Evaluation Group, 2021).

Turner (2021) reviewed project documents from twelve country programs of the initiative that falls under the visionary umbrella of the Great Green Wall, which seeks to rehabilitate degraded lands and reduce the vulnerability of the rural poor in the Sahel. The study revealed little attention to the needs of the most vulnerable, with some of the most vulnerable either excluded or ignored. Similarly, in relation to afforestation projects in China, Rozelle et al. (2000) speak of controversies regarding the treatment of indigenous peoples (in Xizang).

Examining the experience of two decades of Joint Forest Management in India (Bhattacharya et al., 2010), the failure to include people is recognized as a major drawback. The Forest Department's autonomy over allocation and demarcation of forestlands, their control over micro plans and over the disposal of forest produce left little room for people's participation. Worsdell and Sambhav (2020) describe that as part of an afforestation drive in India, traditional lands have been fenced off, and communities who have the right to use this land have been forcibly evicted and left homeless. These conflicts are impacting nearly half a million tribal and forest-dwelling people in India.

Many recent studies present afforestation as a readily available and cost-effective solution to limit and mitigate climate change. However, estimates of afforestation potential vary widely. Moreover, the risks in global mitigation policy and the negative trade-offs with food security are often not considered (Doelman et al., 2020). Oxfam (2021) reports that two of the most commonly used offsetting measures, reforestation and the planting of new forests, were among the worst at putting food security at risk. Far better, are nature-based solutions that focused on agroforestry – the practice of combining crop cultivation or pasture with growing trees – as well as pasture management and soil management in croplands. These would allow people to use the land for food while sequestering carbon.

Nimbalkar et al. (2017) assessed the carbon sequestration potential of wadis (orchards) in the semiarid region Jhadol of Rajasthan in 25 randomly selected wadis planted between 7 to 14 years ago. They were composed of mango (Mangifera indica), amla (Phyllanthus emblica), teak (Tectona grandis), bamboo (Bambusa species) and subabul (Leucaena leucocephala). The study concludes that the total carbon accumulated in a 10-year-old wadi plantation is 23 t carbon per ha, that is, 84.6 t $CO2$ per ha. The total carbon accumulated in wood biomass was 15 t per ha and 8 t per ha in soil.

Sharma et al. (2017) assess the opportunities and challenges of agro- forestry systems in India. The wadi program is not explicitly mentioned but includes agrihorticulture defined as 'fruit orchards/fruit tree based cropping systems as well as 'horti-pastoral systems in hilly orchards for soil conservation' (based on Dagar et al., 2014). According to CAFRI (2015), there is a scope for increasing the area under agroforestry, especially on degraded- and wasteland. However, there is insufficient research on agro- forestry models. In India, it has mostly been conducted on research stations in relatively small plots or/and laboratories, and little or no research has been done on an ecosystem or landscape level. Additionally, most of the studies are of a relatively short-term nature (Sharma et al., 2017).

As the summary of the previous programs and studies reveals, they vary widely in scope and context and mostly contain little formal evaluation. Presently, a rigorous scientific assessment of the impact and effectiveness of fruit trees regarding a holistic beneficial effect on livelihood and the environment does not exist. Anecdotal and indirect evidences, however, suggest a high potential. Next, we briefly describe the wadi Program, which we relied on in our effort to analyze the impact of trees on livelihoods, as the core of this program is the development of orchards to lift people out of poverty. For further details on the program, refer to Nienkerke et al. (2022).

### 1.3 Fruit trees and the wadi concept

The wadi Program was introduced in the Vansda District of Gujarat in the 1980s. Since then, the program has been widely replicated: in 18 districts of Maharashtra, 12 districts of Gujarat, 8 districts of Karnataka, and 15 districts of Rajasthan, including nearly 200,000 families. The design of the program starts with a recognition of the attachment that the smallholders have to their land. Each family is typically provided support over four to five years for the establishment of a wadi on one acre (0.40 ha.) of so-called 'wasteland,' which would not otherwise be used for rainfed crop growing. In consultation with the families, tree varieties such as mango and cashew are selected based on the suitability of the agro-climatic conditions and market potential. Figure 1 shows a schematic depiction of a typical wadi and Table 1 summarizes the measures taken in the wadi Program.

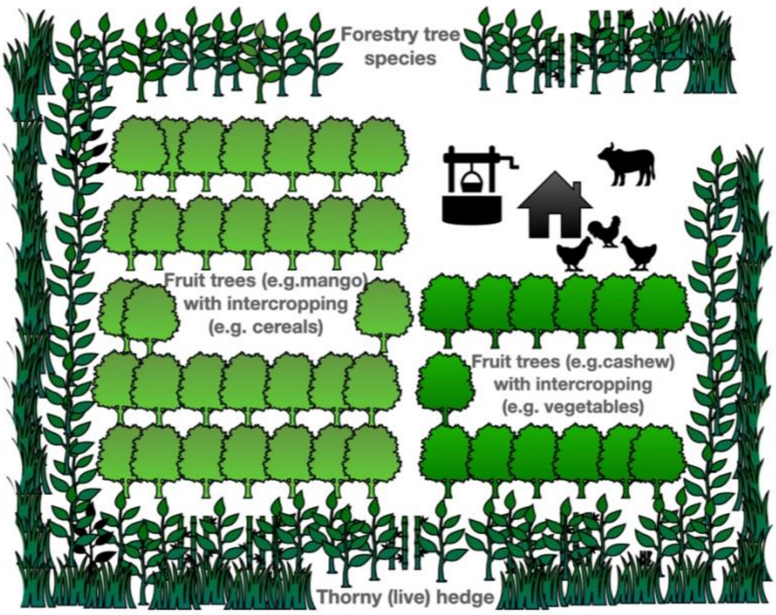


Figure 1: Schematic depiction of a Wadi. Source: Nienkerke et al. (2022a/ in review).

Table 1: Summary of the measures taken in the Wadi program

| | |
|---|---|
| **Agri-horti-forestry** | Typically 50-60 fruit trees are planted in a block on family-owned wasteland plots of around one acre, interspersed with seasonal intercrops. The block is surrounded by 250-400 multipurpose forest tree species and a thorny live hedge, to protect from open grazing cattle. |
| **Soil and water conservation** | The objective is stopping further degradation and improving soil fertility. The velocity of runoff water is reduced and the water has more time to trickle into the ground to recharge the aquifer below. This reduces drinking water scarcity and ensures an adequate supply of water to trees and crops, especially in the summer during the growth stage. |
| **Water resource development** | Site-specific decentralized water resources and rehabilitation of existing ones. |
| **Capacity building** | Regular trainings and field demonstrations in management of horticulture and cash crops, water management, value addition and sale of farm produce, etc. |
| **People's organizations, Cooperatives** | Development of cooperative community organizations to better cope with challenges in the sale of the agricultural products and to ensure appropriate prices. |

## 2 Materials and methods

### 2.1. Mixed methods

We followed a mixed methods approach that started by gathering qualitative evidence, then moved to quantitative evidence to be able to ascertain significant findings, and finally finished with additional qualitative evidence to deepen our understanding of the processes at work. The first step included field visits, participatory rural appraisal, participant-observation and focus group discussions with village representatives as well as (women) self-help groups. Depending on the group, we also used techniques, which take illiteracy into account, such as ranking and drawing.

We interviewed participants as well as non-participants, NGOs, local and international experts, ministers, teachers, health professionals, Indian Development Bank professionals, tribal institutes and development agencies. Based on this, a quantitative survey was developed and conducted face-to-face, lasting between one and two hours. In addition to the main questions on several indicators (see below), a set of questions to the interviewer about how well the respondents understood the questions, a section on geographical context, as well as an open question for remarks and collection of GPS data provided a validity and reliability check and additional insights. After the survey, the interviewers in each state discussed and reported on their personal experiences, impressions, challenges and solutions. Throughout the entire research process, qualitative interviews with stakeholders or local experts were conducted whenever needed for verification or clarification.

**2.2 Core questions**

The survey was divided into the following topics: household demo- graphics, work/seasonal migration, farming and landholding, income, memberships, life changes and perspectives, education, assets, consumption and nutrition, health, water, ethnicity, housing quality, assessment of the location and wadi. Table 2 shows the core questions of the main topics.

In the qualitative research, which helped to frame the context and research questions, we also discussed the daily/annual routine, market access, supply and demand of farm products, bank access, issues on education, drawbacks and benefits of farming and rural/urban life, aspirations and opportunities of the next generation, impacts of infrastructure projects, farming techniques, management of shared water sources, climate change and environmental degradation.

Table 2 Core questions

| Farming, landholding, water: | Life changes and perspectives: |
|---|---|
| • In which year did you plant the wadi?<br>• How many fruit trees were planted?<br>• How many of those trees survived?<br>• Did you expand the wadi yourself after program support ended?<br>• Has water availability changed after wadi establishment? | • On a scale from 1-5, overall, are you satisfied with your life?<br>• Has life changed in the last 5 years?<br>• On a scale from 1/5, Has life become harder or better since the Wadi?<br>• Do you think your children/grandchildren will have a better future/ better perspectives/ more opportunities than you? |

| | |
|---|---|
| • Do you experience changes in the climate / weather pattern?<br>• Assessment of farmland quality<br>• Questions on expenses/farm supply | • Overall, would you say hardship for you has been reduced or increased since the wadi?<br>• Questions on schooling/reasons for drop out |
| <u>Income, assets, housing quality:</u><br>• Now I would like to ask you about what crops (including trees) you grew in the last Rabi, Kharif and summer seasons (even for your own consumption).<br>• For the last year, state the quantity in kg (total production including home consumption) and price/kg (in rupees) for each crop.<br>• Which kinds of livestock do you own?<br>• Does your household own any of the following/ have you spent money on any of the following?<br>• Assessment of house type | <u>Consumption, nutrition, health:</u><br>• Do you consume any of the following food items on a normal day of kharif season / rainy season?<br>• How many meals, including breakfast, do you usually take in your household per day in this season?<br>• Do you have a kitchen garden?<br>• MUAC (measurement of mid-upper arm circumference)<br>• Questions on water availability and quality |

### 2.3 Research design and sampling

The survey was conducted in the four Indian states of Rajasthan, Maharashtra, Gujarat and Karnataka (see Figure 2), representing different geographic regions –overall degraded lands with subsistence- based rainfed agriculture.

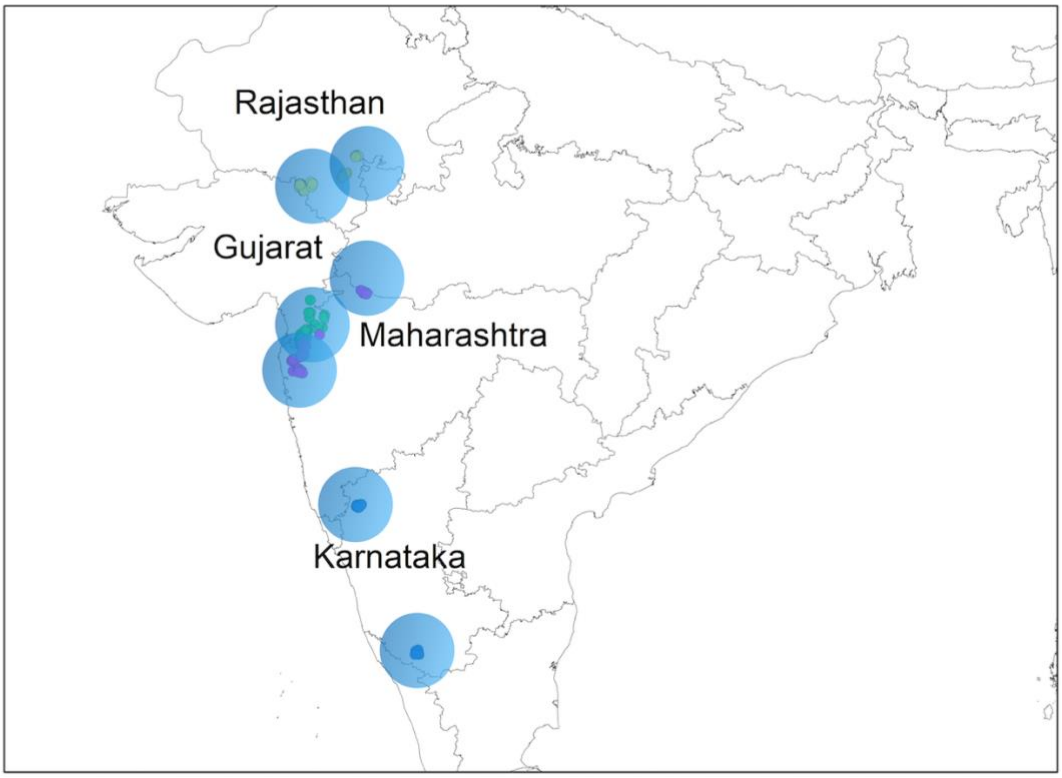


Figure 2: Map of research area. Source: Nienkerke et al. (in review).

The survey involved 1860 randomly sampled households (1132 participants -drawn from a population of 188,231, and 728 non-participants). Our goal was to compare farmers with differing numbers of trees, all other factors being as equal as possible. Thus, we appreciated the way the wadi Program was implemented and its rules for selecting participants, as this automatically produced a natural experiment. More precisely, the program was phased in geographically, over time, incorporating all eligible beneficiaries in one village or region before moving to the next. It was introduced through village and hamlet meetings and exposure visits and all eligible participants were given equal opportunity to participate. Automatically, this system has produced a randomized evaluation design that can provide good internal validity and can rely on weaker assumptions compared with other methods (Gertler et al., 2016). Villages within the program area got the opportunity to join the program within a certain year, while villages outside of this area had to wait. Therefore, both program villages as well as the villages and households located just outside of a program area thus not having the opportunity (yet) to participate, were included in the sample.

The research design, therefore, consisted of three groups: (1) participants in program villages, (2) non-participants in program villages, and (3) non-participating households in villages 5–20 km outside of the program areas (see Figure 3). The control villages were carefully selected in consultation with local experts and based on a catalog of criteria in order to match the program villages with regard to external factors.

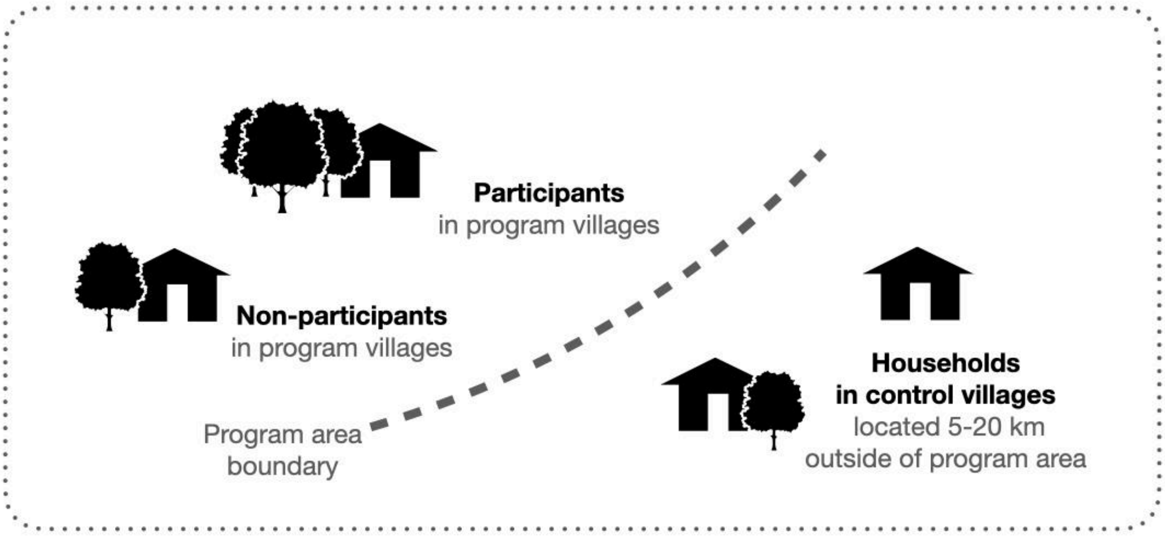


Figure 3: Research design including participants and non-participants in program villages as well as households in control villages outside of program area.

For sampling of participants, the sample was randomly drawn from the population of all households who participated in the program in those four states, totaling 188,231. As a backup, an additional short list with randomly sampled households had been prepared for the rare cases in which the residents of a sampled household were nowhere to be found after returning two times or did not give consent to be interviewed. The questionnaire for this quantitative survey was rigorously tested in the field and translated, in an iterative process. The interviewers were experienced and trained, knew the local context and dialect, and used ODK software (Hartung et al., 2010) on their smartphones. This direct digital input of data and mostly (closed) multiple-choice questions kept possible errors and data cleaning to a limit.

In the analysis, we first used Pearson correlation analysis to test correlations of variables with the variable number of fruit trees. In a second step, we evaluated these results in greater detail by analyzing one variable from each area of life as the dependent variable in step- wise linear regression, taking covariates into account. Subsequently, the strongest influencing factors on the preceding dependent variables are analyzed. Finally, to further scrutinize the causality between fruit trees and benefits, we compare, ceteris paribus, farmers who planted orchards at different points in time.

We decided to keep the message very clear by taking every fruit tree into account for the analysis, irrespective of size and age, thus also small ones, which do not bear any fruits yet. If limiting the analysis to trees yielding harvest, thus of above around 4 years, the impact would be even higher. Figure 4 below shows an overview of the distribution of a number of trees across the sample.

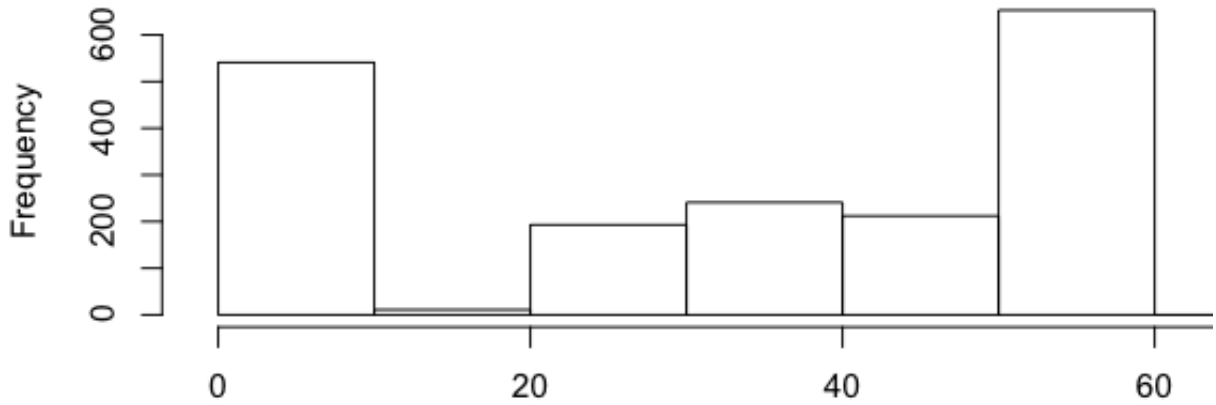


Figure 4: Overview of distribution of fruit trees in our sample

## 3 Results

### 3.1. Impact of fruit trees

We start by examining whether the presence of fruit trees has an
influence on a variety of aspects of life, which we divide into four areas for the sake of clarity, namely (1) economic benefits, (2) social benefits, (3) environmental benefits and climate resilience, as well as (4) local community and economy. Table 3 shows the correlations. The p-value is always below 0.001 and therefore not included in the table. These correlations match our findings from qualitative interviews and focus group discussions. The qualitative information we gathered also helped to establish the causality of the plantation of orchards and the observed impacts.

Table 3: Correlations of number of fruit trees with the most important variables. The *p*-value is always below 0.001 and therefore not included in the table.

| | Correlation with number of fruit trees |
|---|---|
| **Economic benefits** | |
| Number of income sources | 0.32 |
| House type | 0.22 |
| Farming income | 0.22 |
| Income | 0.21 |
| | |
| **Social benefits** | |
| Decrease in hardship | 0.44 |
| Positive life changes in the last 5 years | 0.43 |
| Kitchen garden | 0.41 |
| Life satisfaction | 0.37 |
| Children better future, perspectives and opportunities | 0.30 |
| Life better since plantation of orchard | 0.3 |
| Years of education under 18 (household average) | 0.12 |
| | |
| **Environmental benefits and climate resilience** | |
| Water availability after tree plantation | 0.54 |
| Productivity per unit area | 0.33 |
| Harvest loss of fruit trees (percentage) | -0.3 |
| | |
| **Local community and economy** | |
| Own wadi expansion | 0.61 |
| Attending village meeting last year | 0.24 |
| Someone staying at home since plantation | 0.15 |

In the *economic sphere*, fruit trees have a positive impact on the number of income sources, house type, income from farming and overall income. We were told that even from 10 fruiting mango trees, a family makes a living for four months. The orchards constitute a capital formation, which increases the credit worthiness of the farmers and their self-confidence; they further invest in improvements to their land and diversify their income sources, for example into livestock or vegetable cultivation. This does not only mean additional income but is an important risk hedging strategy as it increases their resilience in case one income source fails. Many households improve their houses and standard of living and have acquired several assets for the first time, like pumpsets, radio, bicycles, mobile phones and livestock.

Regarding *life and social issues*, fruit trees correlate positively with the average educational years completed for people under 18 in the household, as well as the statement that parents expect a better future, perspectives and opportunities for their children. Also, that hardship decreased since the plantation of fruit trees, that positive life changes took place in the last five years, that life is better since the establishment of an orchard, and a positive correlation between fruit trees and life satisfaction. “Horticulture plants don’t require so much of hard work.” There is a positive correlation between the number of fruit trees and whether households cultivate a kitchen garden. Farmers explained that as a result, they enjoy a richer and more diverse diet. In qualitative interviews, we learned that owning an orchard is a status symbol, associated with kings and landlords of ancient times and working hands-on as a single farmer or family to transform their own wastelands into assets helped small farmers to feel knowledgeable and empowered, giving them a sense of happiness and fulfillment and strong emotional and spiritual security. Some women expressed: “we can consider wadi as our earning son who will stay with us forever.”

Concerning the *environmental impact*, we found a positive impact on water availability after tree plantation and productivity per unit area. The water-feeding roots of the trees go deep and do not compete with the surrounding crops for moisture. When asked for reasons for water increase, 24% replied “plantation of trees”. The main reason mentioned for water decrease was “less rain” (15%). Fruit crops produce larger biomass than field crops per unit area resulting in more efficient use of resources (Raj & Chandrawanshi, 2016). A well-developed orchard becomes a rich ecosystem that can sustain several other income-generating activities like dairy farming, which also provides manure as fertilizer. The quantitative assessment of soil improvement was out of the scope of this paper, but qualitative findings are in line with Laganière et al. (2010), that trees have a positive impact on SOC stocks, particularly in cropland soils and with broadleaf species. Also, the orchard trees supposedly act as wind barriers, prevent crop damage due to high winds and help soil conservation. Number of fruit trees has a negative impact on the harvest loss of fruit trees. This is consistent with anecdotal evidence on *climate change resilience*: “unseasonal rainfall causes damage to our rice and wheat crops; if we had (more) horticulture plants, then this loss wouldn’t have happened or would have been very less.” 80% of all surveyed people report to experience changes in climate or weather pattern, independently of the number of their fruit trees, namely (in order of magnitude) stronger/longer rainfall, delayed rainfall, erratic rainfall, temperature increase, dry spells, longer dry season/drought and frost. Also, the microclimate created within the orchards is more favorable for cultivating other crops or vegetables (intercropping) than on barren wasteland. An increase in biodiversities, such as dragonflies, butterflies and other insects, as well as an increase in groundwater recharge, was observed but not scientifically assessed as part of this study. Based on the calculations by Nimbalkar et al. (2017), we estimate the carbon sequestered in the orchards of our study area (188,231 families, approximately 80,000 ha.) to be 1.84 million t C, equivalent to the removal of 6.7 million t CO2 from the atmosphere within 10 years.

Positive correlations with respect to *village life and local eco*nomy were found between the number of fruit trees and whether people attended a village meeting last year and whether they further expanded their orchards. "Obviously we established a new orchard, because we got benefits from the existing one." Many who were skeptical in the beginning become convinced and develop a new wadi. Furthermore, there is a positive correlation between the number of fruit trees and whether someone in the household who seasonally migrated before is now staying at home.

### 3.2 Linear regression analysis with covariates

To evaluate these results in greater detail, and confirm significance when taking co-variates into account, we analyzed one variable from each area of life as the dependent variable in a stepwise linear regression. Table 4 shows these results.

Table 4: Stepwise linear regression for (1) farming income in rupees (2) positive life changes in the last five years, measured on a scale from 1-5 (3) productivity per unit area, measured on a scale from 1-5 compared to average and (4) own expansion of orchard (i.e. planting (more) fruit trees without program or other external support. Income in Indian Rupees.

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | Farming income (1) | Positive life changes in last five years (2) | Productivity per unit area (3) | Own Wadi expansion (4) |
| Program participation | 11,214.120*** (3,444.933) | 0.120*** (0.033) | 0.064* (0.033) | 0.117*** (0.026) |
| Number of fruit trees | 313.975*** (68.977) | 0.007*** (0.001) | 0.006*** (0.001) | 0.011*** (0.001) |
| Irrigated land (acres) | 9,574.412*** (870.454) | | | |
| Own landholding (acres) | 1,494.639* (763.415) | | | |
| Farming income | | 0.00000*** (0.00000) | | -0.00000*** (0.00000) |
| Total people | | 0.015*** (0.006) | | 0.019*** (0.004) |
| Distance water source | | | -0.025** (0.012) | |
| Constant | 3,150.095 (2,757.852) | 2.400*** (0.035) | 0.138*** (0.034) | -0.085*** (0.027) |
| Observations | 1,860 | 1,860 | 1,757 | 1,860 |
| $R^2$ | 0.145 | 0.204 | 0.104 | 0.387 |
| Adjusted $R^2$ | 0.143 | 0.202 | 0.103 | 0.385 |
| Residual Std. Error | 50,732.360 (df = 1855) | 0.496 (df = 1855) | 0.487 (df = 1753) | 0.390 (df = 1855) |
| F Statistic | 78.677*** (df = 4; 1855) | 118.843*** (df = 4; 1855) | 68.099*** (df = 3; 1753) | 292.346*** (df = 4; 1855) |
| *Note:* | | | | *p<0.1; **p<0.05; ***p<0.01 |

All models have been controlled for the impact of overall program support (treatment) and the impact of fruit trees in all models has been found to be significant, even taking the program into account. In (1): we see that on average, the annual income of a household's income from farming increases by 314 rupees per tree. Size of landholding and especially the area of irrigated land also show a significant effect. (2): Besides fruit trees, life is positively changed by farming income and household size. (3): Fruit trees but also a smaller distance to the nearest water source have a positive effect on land productivity. (4): Household size and the number of fruit trees have a significant effect on farmers' decision to further expand their orchards to plant more trees. Also, the smaller the income from farming, the more likely they are to expand the area under fruit trees.

### 3.3 Comparison of important factors

In the variable comparisons (visualized below in Figure 5), we examine the relative importance of different variables by using standardized beta values (beta coefficients). These have a mean of 0 and a standard deviation of 1. The larger the absolute value of the beta value, the greater the observed effect. The beta coefficients show that the variable number of fruit trees is responsible for a large change in (1) farming income and for the largest change in, (2) positive life changes in the last five years, (3) productivity per unit area, and (4) own expansion of orchard.

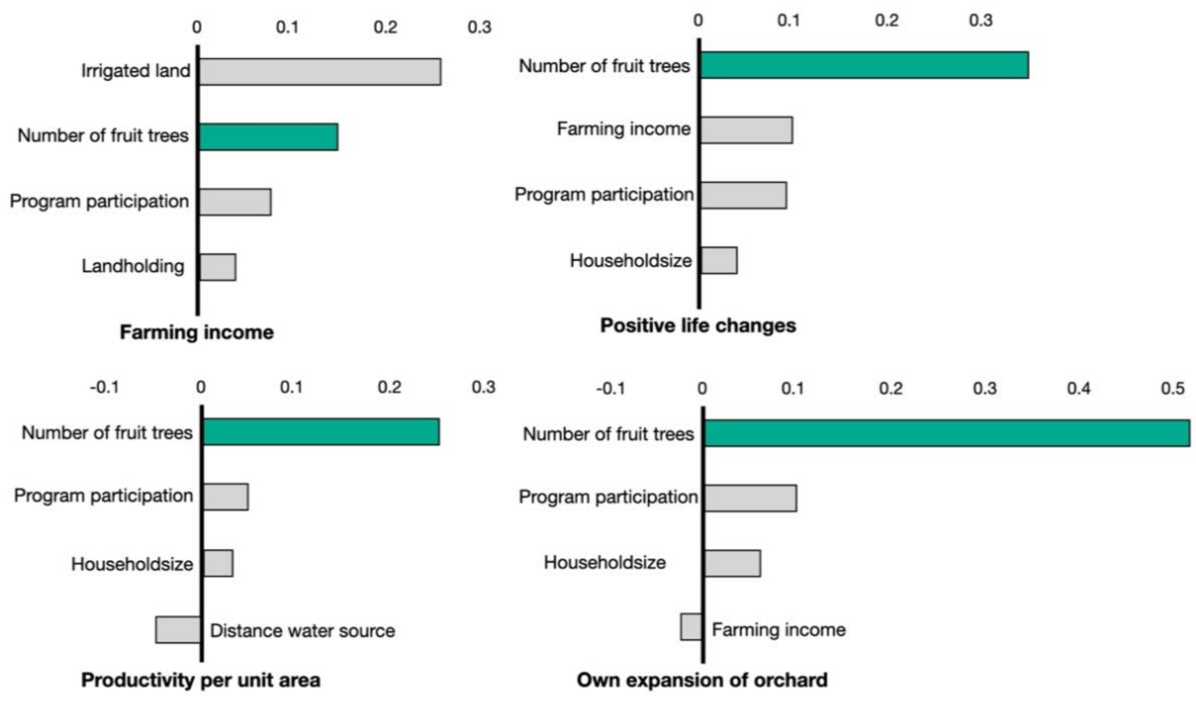


Figure 5: Factors found to be significant in regression model (1) farming income (2) positive life changes (3) productivity per unit area (4) own expansion of orchard. Displayed as beta coefficients.

### 3.4 Impact of fruit trees over time

To fully explain the causal relationship between planting fruit trees and impacts, we undertook an additional analysis, comparing, ceteris paribus, farmers who had planted orchards at different points in time, dating as far back as 23 years. Following up on the above results, we examined the effects on income, positive life changes, productivity per unit area, and own expansion of orchard. All four analyses show that the more years have passed since the establishment of the plantation, the higher the impacts. In the case of income, we can see a clear difference between orchards of 5 years and older (see Figure 6). This is explained by the fact that after approximately five years, the fruit trees start bearing fruits and thus provide the owner with additional income. This trend is also reflected in the perceived positive life changes, where the biggest change takes place after 5 years. The productivity per unit area (compared to average) increases steadily over time, as trees mature, organic material accumulates and because the effects of soil conservation measures and other techniques to increase soil fertility such as vermicompost, manifest themselves only after some time. The finding that over time more farmers increase their number of fruit trees can have two explanations, both of which were confirmed in qualitative interviews: First, over time, farmers become aware of the clear benefits of cultivating fruit trees; second, farmers earn (additional) income by cultivating fruit trees, which they choose to invest in additional trees.

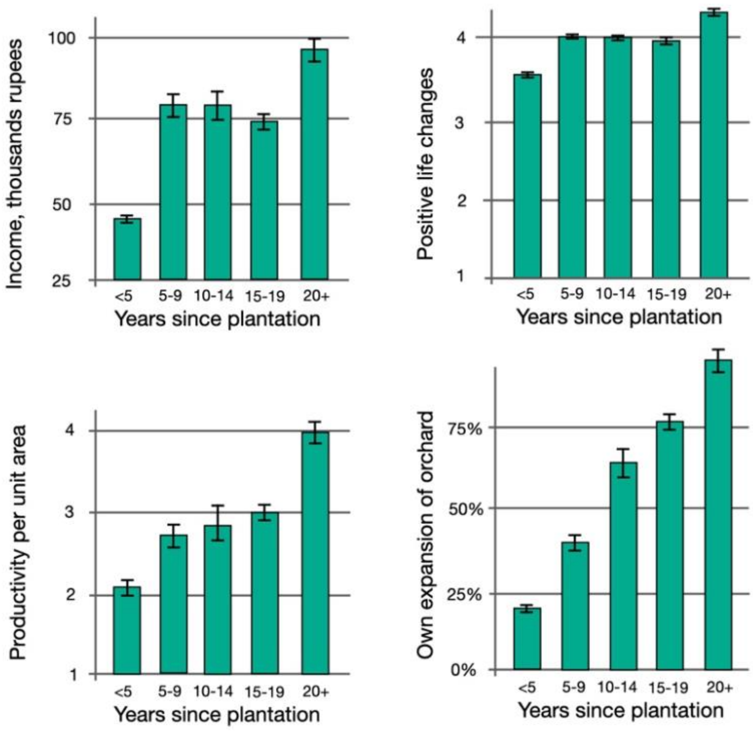


Figure 5: Impacts of planting fruit trees over time (1) farming income in rupees (2) positive life changes in the last five years, measured on a scale from 1-5 (3) productivity per unit area, measured on a scale from 1-5 compared to average and (4) Percentage of farmers who reported own expansion of orchard (i.e. planting (more) fruit trees without program or other external support).

## 4 Discussion

### 4.1 Transformative effects of fruit trees

Can fruit trees transform wastelands and lift marginalized smallholders out of poverty? Yes. Our findings show that cultivating fruit trees can reverse ecological degradation and improve productivity, income, livelihoods, perspectives, dietary diversity, educational levels and perspectives substantially. The combination of horticulture, forestry and intercropping on one acre of degraded and underutilized land constitutes a space-optimized multi-cropping system, providing both food crops for self-consumption as well as cash incomes. Even small farmers with holdings of less than one ha can improve their socio- economic status. The concept is thus highly remunerative for replacing subsistence farming and poverty in the rain-fed, dry land, arid agro-ecosystems and so-called wastelands. This is particularly noteworthy considering the fact that Indian agriculture faces diverse challenges and constraints due to growing demographic pressure, increasing food, feed and fodder needs, natural resource degradation and climate change (Dhyani et al., 2013). Agroforestry should thus be regarded as a shining approach, merging old knowledge with modern science in one system. It is a concept of thinking small scale to achieve potentially big and transformative outcomes (Steiner, 2012).

### 4.2 Holistic approach

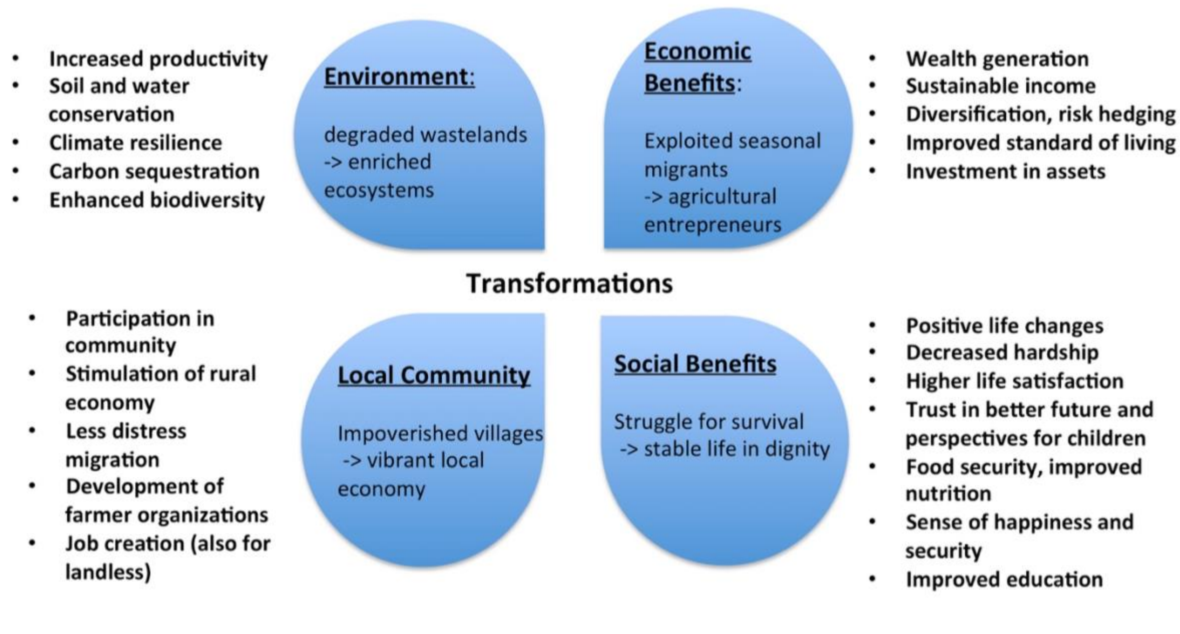


Figure 7: Summary of the various transformations and benefits of planting fruit trees in a holistic approach

By dealing with the issues of poverty alleviation and environmental regeneration in a holistic manner, a sustainable outcome and a broad range of positive impacts and transformations were reached. The various benefits are visualized in the overview above.

As shown in Figure 7, the transformations affect various areas of life, namely: (1) environmental benefits and climate resilience, (2) economic benefits, (3) social benefits, as well as (4) the local community and economy. (1) The plantation of fruit trees on degraded wastelands enriches the ecosystem without disturbing the existing cropping pattern since only fallow land is brought under cultivation. Furthermore, there is potential for climate change adaptation as well as mitigation (Chavan et al., 2015; Singh et al., 2013). (2) The fruit trees enable the participants to generate cash income while they meet most of their food requirements from intercrops, such as millets, which are not high paying but provide food security. As farmers now have a sustainable income and job security on their own land throughout the whole year, they are spared the agony of distress migration, invest in their own land, adopt new technologies and diversify. Exploited seasonal migrants become agricultural entrepreneurs. (For details on the impact on migration, see Nienkerke, Thorat, & Patt, 2022) (3) This economic upliftment as well as 'anchoring' effect of the fruit trees replaces the struggle for survival with stable lives in dignity. In addition to economic profits, intangible social benefits are created in form of decreased hardship, improvement in educational levels, food security, nutrition and health, as well as a surge in confidence acquired through increased knowledge and abilities. (4) Benefits are not limited to the households owning orchards but transform the whole local community. As people stay in the village throughout the year, they increasingly participate in the community and invest in their land. The agricultural activities energize the local economy as they lead to the overall growth of markets and agri-businesses and create opportunities for direct and indirect local employment (also for landless families), such as processing and marketing, often through newly developed farmer organizations. (For more details on spillover effects, please refer to Nienkerke, Thorat, & Patt, 2022).

### 4.3 Key success factors

It became clear that to reach these multidimensional positive outcomes successfully, three factors were key. (1) The program follows a holistic approach; it has a well-defined central theme but also considerable built-in flexibility. (2) It addresses the area-specific needs and (3) involves the smallholders themselves in every stage of the development process. Obviously, success does not come overnight, (for more details on lessons learned and key success factors, refer to Nienkerke et al. (2022)). Overall, to break the 'vicious poverty and resource degradation cycle' described by Sreedharan and Matta (2010), in which environmental degradation further reduces productivity and forces those who are already poor and vulnerable into a downward spiral of increasing poverty, development planners need to look beyond “trees.” To ensure a win-win situation for the environment and livelihood opportunities, the participation of disadvantaged groups is crucial (Ullah et al., 2021). Where land is used for nature- based projects, it must prioritize food security, build the resilience of small-scale farmers and strengthen the rights and livelihoods of local communities.

### 4.4 Role model for replication

This successful agricultural development activity in India can be a role model for wider replication. Since rainfed agriculture covers a significant portion of land and share of total production in Africa, Asia and the Pacific, diversification into horticultural crops could bring prosperity and nutritional security to other rural communities as well. It makes more efficient use of small landholdings, scarce water resources and high labour/land ratios, taking full advantage of family labor and creating off-farm jobs. In the case of India, it is estimated that the area under agroforestry can be increased by another 28.0 M ha (CAFRI, 2015) and most could come from degraded wastelands, thus without curtailing the area under food crops but instead providing the resources to meet livelihood and food security along with the economic growth in the region (Singh & Dhyani, 2014). In any case, before replicating the program elsewhere, a feasibility study is recommended, as opportunity costs for poor small-scale farmers would be high.

We assessed the potential of fruit trees in the context of the natural resource degradation and human vulnerability nexus, providing better insights into the causal links, generating an understanding that can bridge the existing gap of projects that have been scientifically evaluated as successful, and thus feed into the design of future programs to lift smallholders elsewhere out of chronic poverty too. The fruit trees literally rooted farmers to their land and changed livelihoods and landscapes: previously, farmers were impoverished and villages abandoned for most of the year, the landscape deserted. Now, the barren wastelands are converted into green assets and villages are transformed into vibrant communities.

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