DECISION-PROCESSES CONCERNING THE MANAGEMENT OF ECOSYSTEM SERVICES FOR ECOSYSTEM-BASED ADAPTATION TO CLIMATE CHANGE

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Summary

An increasing production of scientific literature addresses the past, current and future importance of ecosystems for the provision of goods and services to society. However, pressure from climate change, national policies and globalization are increasingly degrading this capacity of ecosystems. Typically, the design of societal responses to ecosystem services degradation requires considering the decision-making of multiple actors from the local scale where ES are provided to regional, national and international scales where decisions on rules and resources are defined and distributed. This is the case of SRS degradation which requires consideration of decision processes also considering the on- and off-site benefits of SRS. Indeed, soil erosion affects upstream land users and downstream user as hydropower dam due to siltation. Moreover, in a watershed, these actors directly benefiting from and making decisions regarding SRS are embedded in decision processes happening at scales that go beyond the watershed and beyond the direct use of SRS services (e.g., decisions to design technical solutions to soil erosion, decision on the provision of incentives and their types, etc.).

The goal of the thesis is to analyse the multi-hierarchy human decision processes characterizing SRS provision considering the human and environment system as two different, complementary and interrelated systems. In this thesis I analyse the case study of Soil Regulation Services (SRS) in the Birris watershed Costa Rica, a country pioneer in policies to protect ecosystem services. The Birris watershed is a relatively small territory with an area of 5800 has. It is characterized by intensive and market-oriented agricultural production activities with high fragmented farm areas and steep slopes. Soil erosion has been increasing since several decades due to inadequate land use practices and increasing extreme precipitation events whose intensity and frequency is expected to grow under climate change. The Birris watershed represents a learning case for many national and regional actors due to its commonality with other watersheds in the region.

The first of four articles of this thesis analyzes the environmental dimension focussing the role of forest ecosystem cover on hydrological responses. In the following three papers I address the human dimension focusing on decision processes occurring at different scales: i) from the individual farmers decision-making on soil conservation; ii) to the watershed scale where actors are directly affected by on-site and off-site provision of SRS; and, finally, iii) to the national cross-scale information-sharing network of multiple actors involved directly or indirectly (scientists,
regulators, farmers’ associations, users of SRS, etc.) in the management of watersheds and of SRS.

More specifically, the goal of the first paper is to synthesize the findings of several paired-catchment experiments from Africa, Asia and Latin America that analyze the effect of forest cover change on hydrological responses. We use meta-analysis as a tool used in ecological studies to synthesize results from different studies. This help us overcoming the small “n” problem associated to many of these types of forest hydrology studies in watersheds especially in developing world.

The second paper addresses the complexity of farmers’ decision-making in respect to soil conservation decisions. This is analyzed through a multi-dimensional decision model including economic cognitive and territorial variables influencing farmers’ decision-making regarding soil conservation efforts. The structured survey included items built through previous meetings with farmers to capture their perspectives and understanding on soil erosion and its solutions.

The goal of the third paper is to analyze aspects that are relevant to build a collaborative mechanism among users of on-site and off-site provision of SRS. Specific methods from decision science and negotiation analysis are applied implying consultations with both users and providers of SRS. In separate meetings, consultations allowed structuring their fundamental objectives and identifying key aspects of composing a desired mechanism such as: i) how to select farmers; ii) what type of contract should be used; iii) who should intermediate and, finally, iii) the type of possible incentives for farmers’ soil conservation. In order to identify negotiation space for key aspects of a mechanism, preferences of both stakeholders in respect to different alternative aspects of a mechanism were elicited in two separate focus groups.

The goal of the fourth paper is to identify cross-scale institutional mismatches arising from formal policies and mandates and constraining SRS provision and use. We use “betweenness centrality” algorithm (common to social network science) to test how structural analysis of information-exchange network can identify boundary organizations which are potentially strategic to overcome cross-scale institutional mismatches. We analyse actors’ official mandates contributing directly or indirectly to SRS provision and their interaction in information-sharing network.

The analysis of the environmental dimension proves the usefulness and methodological limitations of using meta-analyses to synthesize findings from paired-catchments experiments.
studies on the hydrological effects of changes in natural and planted forests cover. Overall results from experiments from Asia, Africa and Latin America show that forest cover can play an important role in diminishing the base flow in watershed but its effect on storm-flow control (i.e. water runoff causing erosion) depends more on local characteristics. Some methodological limitations from this use of quantitative meta-analysis can also be outlined. We found a relatively small number of paired-catchment experiment studies from Asia, Africa and Latin America thus limiting the capacity to analyze the interacting effect of important factors for water flow regulation, such as soil, geology, topography, or land management practices. As for the capacity of forests to control storm flows (related to increase in erosion) data found in the scientific articles used in the meta-analysis did not allow accounting for the effects of frequent and intense extreme precipitation events. This also limits the capacity to compare the provision of SRS under climate change from natural forest ecosystem vs non-forest land uses such as conservation agriculture.

At the local scale, farmers’ awareness of their exposure level to soil erosion combines with other variables to determine their level of soil conservation efforts. The decision model includes socioeconomic, territorial and cognitive variables such as beliefs, values and risk perception and clearly separates three groups of farmers based on their soil conservation efforts. Most farmers are aware of the risk of erosion although socioeconomic aspects such as type of production and farm size indicate that perceived opportunity cost given the farm production context might hinder their conservation efforts. Farmers with low perception of erosion risk might also be expressing “availability heuristic” paradigm due to their daily experience with erosion in the watershed.

At the watershed scale, the design of collaborative efforts for the on- and off-site provision of SRS requires agreement on the fundamental objectives of a mechanism for collaborative efforts for soil conservation. Consulted farmers and hydropower agree on the importance of the promotion of learning through technical assistance and monitoring of soil conservation programs and the fair distribution of incentives. Direct payment for soil conservation is only limitedly considered as a desired incentive alternative. Consistent with the fundamental goal of promoting learning, technical assistance is seen as a more desirable alternative than direct payments.
The national cross-scale analysis of governance structure for SRS highlights that important regulatory mismatches affect the definition of societal responses at the local level (i.e. where direct actions to promote adequate provision and use of ES happen). Network analysis helps us identifying the information-bridging characteristics of actors in informal information-sharing networks. This analysis outlines the boundary role of the watershed agricultural-extension office helping diffusing information on impacts as well as social and technical feasibility of responses to SRS degradation across-scales and policy areas.

Overall the thesis’ results show that soil conservation policies to support the provision of SRS would benefit from the use of mixed policies. This might include programs to raise awareness on current and future soil erosion risks, promote learning among farmers, and institutionalize the boundary role of agricultural extension offices for their importance to promote learning and adaptive management of SRS. This is especially valuable in the context of areas highly exposed to increasing frequency of extreme precipitation events such as Central America. Moreover, in the face of high uncertainties and scarcity of data (e.g. on the impacts of land use/management and climate change), mechanisms to update and disseminate information over time on impacts on soil erosion and correspondent solutions are required. In this respect, strengthening the boundary role of agricultural-extension office can potentially help updating information available to scientists, regulators and farmers on impacts and social and technical feasibility of solutions. This might prove a strategy to address some of the regulatory mismatches that hinder responses to SRS degradation at local level and promote adaptive management of soil regulation services.
**Zusammenfassung**


Einzugsgebiet dient als Lernbeispiel für nationale und internationale Akteure, da es viele Gemeinsamkeiten mit anderen Einzugsgebieten aufweist.


Mechanismen zu identifizieren, wie beispielsweise: i) wie sollen die Bauern ausgewählt werden; ii) welche Kontakttypen sollten verwendet werden; iii) wer sollte Konflikte schlichten und schliesslich iv) welche Arten von Anreizen gibt es für Bauern für die Umsetzung von Bodenerhaltungsmassnahmen. Um die Verhandlungsspielräume für die Hauptaspekte des Mechanismus zu erkennen wurde mit jeder Akteursgruppe eine separate Fokusgruppe durchgeführt und die Präferenzen der Akteure zu verschiedenen alternativen Aspekten eines Mechanismus eruiert.


kontrollieren (welche zu erhöhter Erosion führen) erlaubten es nicht, die Effekte häufiger und intensiver Extremniederschläge zu berücksichtigen. Dies schränkt auch die Vergleichsmöglichkeit von der Bereitstellung von Bodenregulierungsdienstleistungen unter Klimawandel durch natürliche Waldökosysteme und nicht-Wald Landnutzungen wie beispielsweise Conservation Agriculture (Landwirtschaft mit konservierender Bodenbearbeitung), ein.


Die nationale ebenenübergreifende Analyse von Lenkungsstrukturen für Bodenregulierungsdienstleistungen betont, dass wichtige regulatorische Diskrepanzen lokale gesellschaftliche Reaktionen beeinflussen (d.h. da, wo direkte Handlungen zur ausreichenden Bereitstellung und die Nutzung von Ökosystems-Dienstleistungen stattfinden).

Mittels Netzwerkanalyse können wir die informationsüberbrückenden Charakteristiken von Akteuren in informellen Informationsaustausch-Netzwerken identifizieren. Diese Analyse streicht
die Schlüsselrolle von landwirtschaftlichen Beratungsbüros im Einzugsgebiet hervor, welche bei der Verbreitung von Informationen zu Umwelteinflüssen und technischer Umsetzbarkeit von Bodenschutzmassnahmen helfen, und dabei Informationen über Politikbereiche und Ebenen hinaus austauschen.