

Governmental Payments for Ecosystem Services Programs in China

The Institutional Settings and Market-based Approach

Dissertation

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This work is dedicated to my loving daughter Zeling. Thanks to my wife Qian, my mother Yabing Wu and my father Ming Chen for all their great support!

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Preface & Acknowledgements

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Summary

My dissertation focuses on institutional aspects of governmental payments for ecosystem services (PES) in China. Market-based approaches for ecosystem service governance, particular the PES, have been considered new and innovative policy instruments over the past decades. Corresponding to this international trend, PES schemes in China are mostly described by the domestic term eco-compensation. However, the characteristics of eco-compensation are distinct from other national PES programs, as governance model, property rights and societal structures in China are different to the PES theory. Eco-compensation faces many institutional challenges in creating economic incentives for behavioral change. However, PES that combines elements of both a voluntary market and hierarchy-based system in dealing with incomplete institutional settings has not yet been sufficiently addressed. In particular, there is a knowledge gap regarding fitting the design of PES and institutional settings in China together.

The mechanisms of PES in China differ in important ways from mechanisms familiar from the western experience. This dissertation aims to reduce the divergence between the common framing of PES and the reality of its practice by presenting the institutional analysis of China's governmental PES program. As a major component of eco-compensation, the Sloping Land Conversion Program (SLCP) is considered one of the world's largest PES programmes. By taking SLCP as an empirical case, the first objective of this dissertation is to understand how to improve the institutional design of governmental PES. The second lies in a broad international context, aiming at methodologically contributing to the analysis of ecosystem services governance. This dissertation follows a cumulative structure, integrating the framework text and five papers.

Chapter 1 is an introduction, outlining the research gaps and objectives of governmental PES. Chapter 2 provides a theoretical foundation to the institutional economic schools, their respective theories and the relevance of nature resource governance in China. Based on this, Chapter 3 confirms the research design by deconstructing the research objectives into different research questions. Chapter 4 is the results section, which comprises five papers. The first paper provides the

conceptual basis for all subsequent studies presented in this dissertation, as it is an overview of the effectiveness and institutional challenges of China's Sloping Land Conversion Program (SLCP). Both the second and third papers are empirical works. The second paper explores how socioeconomic and institutional conditions encourage rural households to reach the primary environmental goals of SLCP. The third paper shows how local dynamics derived and shaped the SLCP's implementation. The fourth paper illustrates and discusses the method used in paper 2, comparing it with another case study in Germany. Finally, the fifth paper presents the strengths and weaknesses of the method used in paper 3 based on the experiences of four different countries. Together, these papers deliver important contributions to both objectives. Chapter 5 is the synthesis and discussion, and Chapter 6 concludes the dissertation.

The key finding of this dissertation is that the effectiveness of governmental PES is a result of interacting driving forces, whereas institutional settings and local dynamics play key roles in shaping program implementation. The SLCP could achieve its potential in creating significant economies of scale and environmental effectiveness under certain institutional conditions. However, against incomplete institutional settings, the current implementation of SLCP has deviated substantially from the market approach promoted by policy makers. While the incomplete institutional settings did not prevent SLCP's wide acceptance and fast development in its first phases, there is no by-pass to reach the long term success in terms of environmental effectiveness in the absence of key PES elements. The program's predominantly top-down approach and lack of genuinely voluntary characteristics, conditionality and property rights are jointly understood to be critical factors that explain possible failures in the long-term.

Another contribution which this dissertation makes is in methodological approaches of ecosystem service governance. This dissertation has shown that mixed approaches combining qualitative and quantitative methods, such as Qualitative Comparative Analysis (QCA) and social network analysis (SNA), could have great potential for institutional analysis and participatory research for PES. The two methods were given particular emphasis in the detailed description of application, as well as in the inherent merits and limitations.

Zusammenfassung

Meine Dissertation beschäftigt sich mit den institutionellen Aspekten staatlicher Zahlungen für Ökosystemleistungen (Payments for Ecosystem Services „PES“) in China. Marktbasierte Ansätze zur Steuerung von Ökosystemleistungen, insbesondere von PES, wurden in den letzten Jahrzehnten als neue und innovative Politikinstrumente angesehen. Entsprechend diesem internationalen Trend sind PES auch in China populär, werden jedoch meist mit dem inländischen Begriff der Ökokompensation beschrieben. Einen wirtschaftlichen Anreiz für Verhaltensänderungen zu schaffen, wenn das Ökokompensations-Programm nur ein Ausgleich für gesetzliche Einschränkungen ist, kann eine Herausforderung darstellen. Die Merkmale der Ökokompensation unterscheiden sich von anderen nationalen PES-Programmen, da sich das Governance-Modell, die Eigentumsrechte und die gesellschaftlichen Strukturen in China stark von anderen Staaten unterscheiden. Die Ökokompensation steht vor vielen institutionellen Herausforderungen, wenn es darum geht, ökonomische Anreize für Verhaltensänderungen zu schaffen. Zahlungen für Ökosystemleistungen, die Elemente sowohl eines freiwilligen, marktbasierten als auch eines hierarchischen Systems kombinieren, um mit den besonderen institutionellen Rahmenbedingungen umzugehen, wurden bisher noch nicht ausreichend untersucht. Eine Wissenslücke besteht insbesondere hinsichtlich der Anpassung des Designs von PES an die institutionellen Rahmenbedingungen in China.

Die Mechanismen von Zahlungen für Ökosystemleistungen in China unterscheiden sich in wichtigen Punkten von den aus der westlichen Erfahrung bekannten Mechanismen. Die vorliegende Dissertation zielt darauf ab, die Diskrepanz zwischen der allgemein gültigen Rahmung von Zahlungen von Ökosystemleistungen und der Realität ihrer Praxis zu verringern, indem sie eine institutionelle Analyse des chinesischen staatlichen PES-Programms vornimmt. Das Sloping Land Conversion Program (SLCP) gilt als eines der weltweit größten PES-Programme und ist ein wichtiger Bestandteil der Ökokompensation. Das erste Ziel dieser Dissertation ist es, anhand des SLCP als empirische Fallstudie zu verstehen, wie das institutionelle Design des staatlichen PES in China verbessert werden kann. Das zweite Ziel ist in

einem breiteren internationalen Kontext zu sehen und zielt darauf ab, einen methodischen Beitrag zur Analyse der Governance von Ökosystemleistungen zu leisten. Die Dissertation folgt einer kumulativen Struktur, die aus einem Rahmentext besteht, in den fünf, von Experten begutachtete, Artikel aus internationalen Fachzeitschriften integriert sind.

Kapitel 1 ist eine Einführung, in der die Forschungslücken und die Forschungsziele im Hinblick auf staatliche PES beschrieben werden. Kapitel 2 liefert die theoretische Grundlage der institutionellen Ökonomie und zeigt die Bedeutung der Governance von Naturressourcen in China auf. Darauf aufbauend konkretisiert Kapitel 3 das Forschungsdesign, indem es die Forschungsziele in verschiedene Forschungsfragen untergliedert. Kapitel 4 beinhaltet den Ergebnisteil, der fünf Zeitschriftenartikel umfasst. Der erste Artikel liefert die konzeptionelle Grundlage für alle nachfolgenden Untersuchungen, die in dieser Dissertation vorgestellt werden, und gibt einen Überblick über die Wirksamkeit und die institutionellen Herausforderungen des chinesischen SLCP. Sowohl der zweite als auch der dritte Artikel sind empirische Untersuchungen. Der zweite Artikel untersucht, wie die sozioökonomischen und institutionellen Bedingungen Anreize für Haushalte in ländlichen Gebieten schaffen, um die primären Umweltziele des SLCP zu erreichen. Der dritte Artikel zeigt, wie lokale Dynamiken die Umsetzung des SLCP beeinflusst und geprägt haben. Der vierte Artikel veranschaulicht und diskutiert die im zweiten Artikel angewandte Methode im Vergleich zu einer weiteren Fallstudie in Deutschland. Der fünfte Artikel schließlich stellt die Stärken und Schwächen der im dritten Artikel angewandten Methode den Erfahrungen ähnlicher Studien in vier weiteren Ländern gegenüber. Zusammen liefern diese Artikel wichtige Beiträge für die beiden Ziele der Dissertation. Kapitel 5 beinhaltet die Synthese und Diskussion der Ergebnisse und Kapitel 6 schließt die Dissertation ab.

Das wichtigste Ergebnis dieser Dissertation ist, dass die Wirksamkeit des staatlichen PES in China das Ergebnis der Interaktion der treibenden sozialen Kräfte ist, während institutionelle Rahmenbedingungen und lokale Dynamiken eine Schlüsselrolle bei der Ausgestaltung der Programmumsetzung spielen. Das SLCP hätte unter bestimmten institutionellen Bedingungen ein großes Potenzial für die Schaffung signifikanter Skaleneffekte und für die Verbesserung der Umwelteffektivität.

Allerdings weicht die derzeitige Umsetzung des SLCP wegen der besonderen institutionellen Rahmenbedingungen erheblich von dem von der Politik geförderten Marktansatz ab. Zwar haben die institutionellen Rahmenbedingungen die breite Akzeptanz und schnelle Entwicklung des SLCP in der Anfangsphase nicht behindert, doch gibt es keine Möglichkeit, einen langfristigen Erfolg im Hinblick auf die Umwelteffektivität zu erreichen, wenn die wichtigsten PES-Elemente fehlen. Der überwiegend von oben nach unten gerichtete Ansatz des Programms und das Fehlen von echter Freiwilligkeit, Konditionalität und Eigentumsrechten werden zusammen als kritische Faktoren verstanden, die mögliche Misserfolge langfristig erklären.

Ein weiterer Beitrag der Dissertation sind die methodischen Ansätze, die zum besseren Verständnis der Governance von Ökosystemleistungen beitragen. Diese Dissertation zeigt, dass Ansätze, die qualitative und quantitative Methoden kombinieren, wie z.B. Qualitative Vergleichende Analyse (Qualitative Comparative Analysis „QCA“) und Soziale Netzwerkanalyse (SNA), ein großes Potenzial für die institutionelle Analyse und partizipative Forschung von PES haben. Bei beiden Methoden wurde besonderes Augenmerk auf die detaillierte Beschreibung ihrer Anwendung sowie die damit verbundenen Vor- und Nachteile gelegt.

Keywords

Governance of ecosystem services

Eco-compensation

Governance structures

Economic incentives

Sloping Land Conversion Program

Schlagwörter

Governance von Ökosystemleistungen

Ökokompensation

Governancestrukturen

Ökonomische Anreize

Sloping Land Conversion Program

List of Publications

Paper 1

The Institutional Challenges of Payment for Ecosystem Service Program in China: A Review of the Effectiveness and Implementation of Sloping Land Conversion Program.

Chen, C.; König, H.J.; Matzdorf, B.; Zhen, L.

Sustainability, 2015, 5564-5591.

<http://dx.doi.org/10.3390/su7055564>

Paper 2

How socioeconomic and institutional conditions at the household level shape the environmental effectiveness of governmental payments for ecosystem services program.

Chen, C.; Matzdorf, B.; König, H.J.; Zhen, L.

Ecosystem and People, 2019, 15:1, 317-330

<https://doi.org/10.1080/26395916.2019.1676311>

Paper 3

The network of local actors in a governmental PES program: Participatory network mapping for China's Sloping Land Conversion Program

Chen, C.; Schröter, B.; Matzdorf, B.

Working paper

Paper 4

Qualitative comparative institutional analysis of environmental governance: Implications from research on payments for ecosystem services.

Meyer, C; **Chen, C.**; Matzdorf, B.

(Meyer C. and Chen C. shared the first authorship as they contributed equally)

Ecosystem Services, Volume 34, Part B, December 2018, Pages 169-180

<https://doi.org/10.1016/j.ecoser.2018.07.008>

Paper 5

Strength and weaknesses of the Net-Map tool for participatory social network analysis in resource management: experience from case studies conducted on four continents

Schröter, B., Sattler, C., Graef, F., **Chen, C.**, Delgadillo, E., Hackenberg, I., Halle, E., Hirt, A., Kubatzki, A., Matzdorf, B.

Methodological Innovations, May-August 2018: 1–7

<https://doi.org/10.1177%2F2059799118787754>

Further publications relevant to the PhD topic

Protection effect of overwintering water bird habitat and defining the conservation priority area in Poyang Lake wetland in China

Sun C.; König, H.J; Uthes S. **Chen C.**, Li P. Karoline H.

Environmental Research Letters, 2020, (under review)

Comparing the energy transitions in Germany and China: synergies and recommendations

Chen, C., Xue, B., Cai, G., Thomas, H., Stückrad, S.

Energy Reports, 2019

<https://doi.org/10.1016/j.egyr.2019.08.087>

Biodiversity constraint indicator establishment and its optimization for urban growth: framework and application

Sun, C., Xu, S., Wei, Q., **Chen, C.**, Deng, Y., Pei, N., König, H. J.

Environmental Research Letters, 2019

<https://doi.org/10.1088/1748-9326/ab55aa>

Knowledge brokerage for impact assessment of land use scenarios in Inner Mongolia, China: extending and testing the FoPIA approach

König, H. J., Podhora, A., Zhen, L., Helming, K., Yan, H., Du, B., Wübbecke, J., Wang, C., Klinger, J., **Chen, C.**, Uthes, S.

Sustainability, 2015

<http://dx.doi.org/10.3390/su7055027>

List of Abbreviations

CIA Comparative Institutional Analysis

CsQCA Crisp-set Qualitative Comparative Analysis

DCBT Desertification Combating Program around Beijing and Tianjing

EU European Union

ES Ecosystem Services

FsQCA Fuzzy-set Qualitative Comparative Analysis

IPCC Intergovernmental Panel on Climate Change

MA Millennium Ecosystem Services Assessment

NFPP Natural Forest Protection Program

NGOs Non-governmental organizations

PES Payments for Ecosystem Services

PSA Payments for Environmental Services (Costa Rica)

PSAH Payments for Hydrological Environmental Services (Mexico)

QCA Qualitative Comparative Analysis

SFA State Forest Administration

SLCP Sloping Land Conversion Program

SNA Social Network Analysis

TEEB The Economics of Ecosystems and Biodiversity

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1 Introduction

Ecosystems provide various benefits to human well-being. Humans use and modify natural ecosystems through agriculture, forestry, recreation, urbanization, and industry. For centuries, human impact has caused a number of dramatic changes to a variety of ecosystems. As ecosystem goods are often common or public goods, governmental governance structures may strongly influence their provision. Over the past few decades, market-based approaches have been considered to be new and innovative policy instruments, when compared to traditional regulation-based approaches.

1.1 Research background

Although the notion of ecosystem services (ES) has a long history, it was conceptualized in scientific literature less than a century ago (Daily 1997). Initially coined in the field of ecology, the concept of ES had evolved through various discussions in scientific communities. The expansion of the ecosystem service approach beyond specialized academic circles took place in the 1990s, when research on how to identify (Daily 1997), classify (de Groot et al. 2002) and value (Costanza et al. 1997) the ES were released. The concept of ES gained broader attention in 2005, when the United Nations published its Millennium Ecosystem Assessment (MEA). In 2010, a report from Economics of Ecosystems and Biodiversity (TEEB) took up the task of promoting the ES concept to media, the general public and policy makers. Nowadays, ES is no longer just a concept but a framework for connecting scientists, decision-makers, other stakeholders and the general public (Schröter et al. 2014). As the network of ES, Ecosystem Service Partnership (ESP) claims that ES should enhance the science, policies and practices of ecosystems for conservation and sustainable development.

ES definitions have evolved over time and several classifications can be found today. For example, the Millennium Ecosystem Assessment in 2005 placed ES in four categories: (i) supporting services: nutrient cycling, soil formation, primary production; (ii) provisioning services: food, fresh water, wood and fiber; (iii) regulating services: climate and flood regulation, water purification; (iv) cultural services: aesthetic, recreational, spiritual. While markets exist and function well for

some ES, many ES with characteristics of public or common pool resources with incomplete property rights are still outside the current market system (Sattler and Matzdorf 2013). Therefore, some see the potential for using the ES concept to enhance the governance of ES provision (Fisher et al. 2009).

At present, ES are increasingly reaching economic decisions through the widespread promotion of incentive-based instruments such as Payments for Ecosystem Services (PES). PES has been applied as a mechanism for translating external, non-market values of ES into positive financial incentives by paying land users or land owners for the provision of ES (Engel et al. 2008). The PES has not only transcended the academic arena but also governmental policy, as well as the non-profit and private sectors (Gómez-Baggethun et al. 2010).

The definition of PES is not standardized, as different conservation approaches are bundled and co-exist under this concept. In theory, PES is dominated by the Coasean and the Pigouvian theorems. Corresponding to the market-based and user-financed PES in practice, the former defines PES as a voluntary transaction negotiated among private contractors, and sees the key role of market mechanisms for environmental conservation (Wunder et al. 2008). Theoretically, the Coase Theorem is rooted in the idea that private economic actors can reach an optimal allocation of resources without government intervention, but only when property rights are well-defined and transaction costs are low. As one of the most widely-cited authors of PES, Wunder (Wunder 2005, 2015) explicitly defined PES as consisting of voluntary, contractual, conditional and direct payments between ES buyers and ES sellers, in return for adopting practices that secure a well-defined ES.

The Pigouvian theorem includes broader schemes by characterizing the intermediation of the government between those who benefit and those who preserve ES (Pigou 1920, Vatn 2010). The main difference between Coasean and Pigouvian PES schemes is whether the direct beneficiary pays the ES providers or the government acts on their behave. Over the last two decades, Pigouvian PES programs have become common all around the world, as a large number of governmental conservation schemes have adopted PES elements across both developing and developed countries (Wunder et al. 2008, Schomers and Matzdorf 2013). However, deviating from Wunder's 'genuine PES', many Pigouvian programs

are considered 'PES-like'.

Policymakers in China are increasingly interested in innovative approaches to addressing the country's multiplying conservation challenges. Corresponding to the international trend of PES, "eco-compensation" is the most important concept in China for reforming conservation programs (Shang et al. 2018). It is defined as a mechanism to maintain or improve ecosystems by using economic incentives to change land users' actions. Some of the eco-compensation programs were recognized as PES-like schemes, as direct payment is often made by governments and the market mechanism is not yet fully in place (Bennett 2009).

PES is commonly imbedded in broad institutional settings, with a variety of social-ecological systems that do not resemble simple market-based buyer and seller relations. The characteristics of eco-compensation are distinct from other national PES programs, as clarity of property, responsibility fulfillment, executive efficiency, effectiveness, sustainability and equality in China are different to PES theory (Shang et al. 2018). China is undergoing a transition toward a market economy and parallel decentralization within a set of economic, political, and cultural institutions that remain embedded in a top-down, command configuration. Despite the official announcement of market mechanisms, the implementation of eco-compensation relies mainly on government structures, from the national down to the village level. The institutional settings for 'genuine PES' in China are, theoretically, far from ideal. However, China is not the only case of this. Ambiguity of property rights, multiply objectives and state centralized planning systems have been observed in other countries as well (Suhardiman et al. 2013), which may inevitably influence the suitability of the PES. However, most mainstream PES literature does little to explain situations in which there are no well-defined property rights. A new expansion of PES that combines elements of both a voluntary market-based and hierarchy-based system in dealing with incomplete settings has not yet been sufficiently addressed. In particular, there is a knowledge gap with regards to understand PES in China and its institutional settings as a new policy paradigm.

As the flagship of the eco-compensation programs, the Sloping Land Conversion Program (SLCP) is considered one of the largest PES programs in the world. Due to its broad geographic cover, high level of participation and tremendous investment, the

SLCP has drawn substantial attention from the scientific community in China and over the world. There are more than 200 publications on SLPC in the Web of Science and the Scopus database (1999-2018). While most of this research has assessed the program's success in combating soil erosion and poverty alleviation, far less attention has been devoted to describing its institutional aspects. Embracing innovative PES elements, however, the design and implementation of SLCP are embedded in incomplete institutional settings in China. The question remains open as to whether the SLCP is an institutional innovation or just "business as usual" (Bennett 2008). In particular, the dependence of the effectiveness of governmental PES on the institutional arrangement and local actors has been little explored. My dissertation aims to close this research gap and reduce divergence between the common framing of governmental PES and the reality of its practice by presenting an institutional analysis of China's well-known PES program.

1.2 Research objectives

In this dissertation, I aim to investigate and improve understanding of a governmental PES in China, from an institutional economics point of view. I want to conduct a comprehensive and empirically-grounded analysis of the institutional arrangement of a large-scale PES program in China. I expect to contribute to the scientific debate of PES by having insights from China. It is also important to provide timely information to Chinese policy makers, in order to improve the program in the future.

Additionally, in view of the methods employed by existing studies, gaps were identified for participatory and dynamic methodological approaches (Sattler et al. 2018). Since my work employs a combination of quantitative and qualitative methods, including literature review, ecological measurement, village surveys, interviews and social network analysis (SNA), I intend that my experiences of these interdisciplinary approaches contribute to methodological development. Therefore, I present two methods that seem particularly promising in view of analyzing ecosystem services governance.

Correspondingly, I intend to focus on two general research objectives:

Research Objective A: How can the institutional design of governmental PES be improved?

Research Objective B: What method can be used for ecosystem service governance analysis?

1.3 Research structure

The two general research objectives have been addressed by four individual peer-reviewed papers and one working paper. Three papers (cited here as papers 1, 2 and 3) depict the theoretical and empirical issues of governmental PES in China. Another two publications provide a methodological innovation in governmental PES (cited as papers 4 and 5) in an international context. Each paper focuses on a particular topic, which mainly contributes to one of the two objectives. Jointly, these papers provide important contributions to each objective. Within this dissertation's framework, the contributions of the individual paper for the general research objectives are depicted in detail. Therefore, I will deconstruct the overall objectives into more specific research questions, which will then be answered by the five papers (Figure 1).

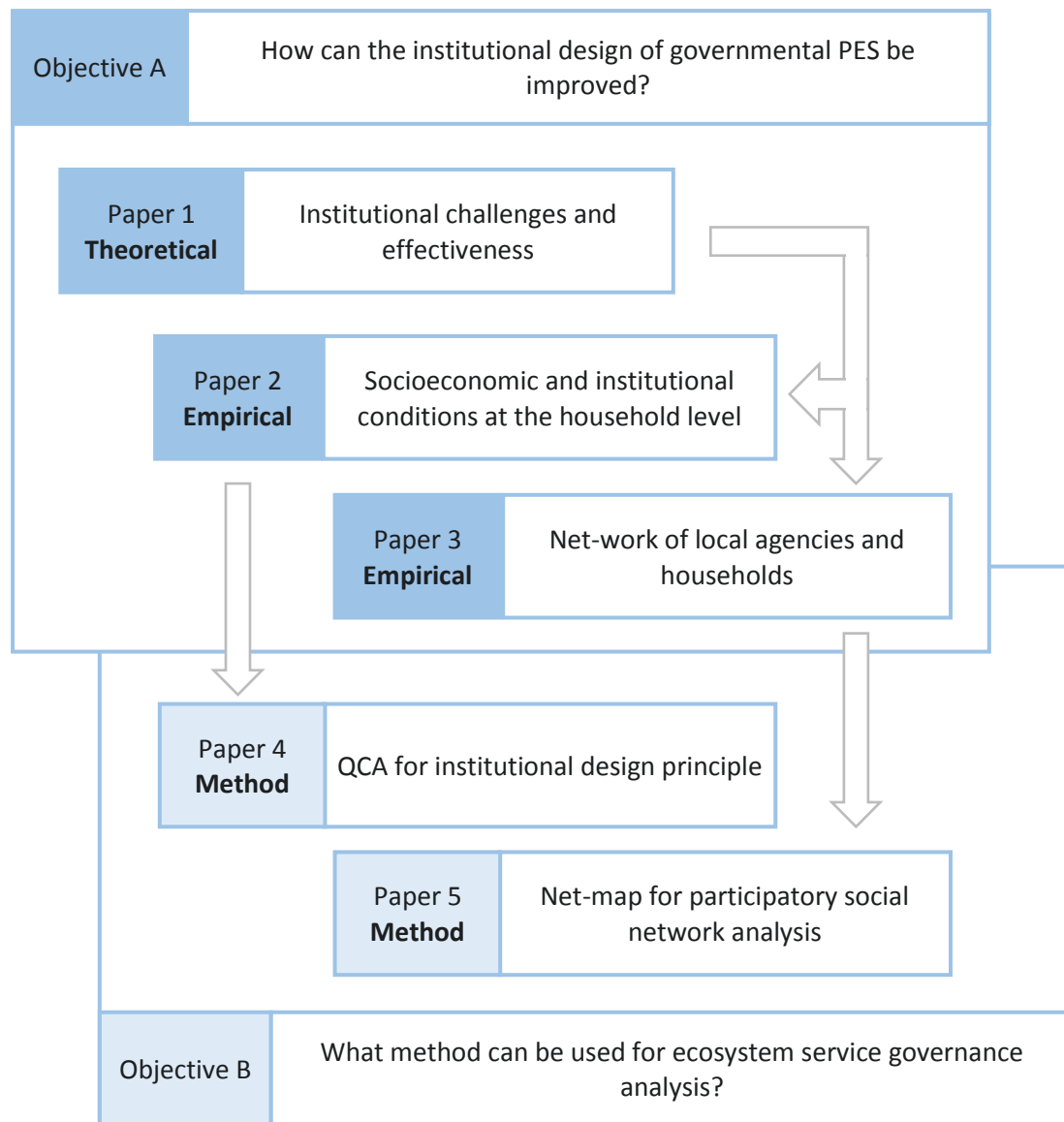


Figure 1: Paper contribution to research objectives

In Section 2, I will present the overall picture by explaining the PES concept and governmental PES. In Section 3, I will solidify the individual research questions based on institutional economics ideas. In Section 5, I will present my answers to the questions raised. Finally, section 6 concludes the dissertation.

2 The PES Concept and Governmental PES

2.1 The PES concept

The PES concept is closely linked to the Coase theorem, in which the beneficiary directly pays the ES provider on a purely voluntary basis, as an outcome of a private negotiation (Coase 1960). In the Coasean sense, Wunder (Wunder 2005, 2015) provides the most widely-cited PES definition, in which PES schemes are characterized as voluntary transactions where a well-defined ecosystem service is “bought” by at least one ecosystem service buyer from at least one ecosystem service provider, if and only if the ecosystem service provider(s) secure(s) the delivery of the service. However, in practice, obstacles to efficient private negotiation such as high transaction costs, power imbalances, or poorly defined property rights can prevent a Coasean solution (Engel et al. 2008).

Opposed to the purely market-based Coasean principle, the PES concept was widened to incorporate the Pigovian approach later on, which promoted environmental taxation and subsidization for the correction of negative externalities (Sattler and Matzdorf 2013). In practice, most PES schemes do not strictly comply with Wunder's definition (Muradian et al. 2010), as they are mostly hybrid governance structures, which also include institutions of hierarchy and community engagement (Vatn 2010, Schomers and Matzdorf 2013)

In summary, PES can be seen as an umbrella term for market-based, hierarchy-based and hybrid structures of ecosystem service management. On the one hand, PES has the potential to contribute to broader solutions for the sustainable use of natural resources. On the other hand, their applicability depends on a good fit to already existing institutional structures and governance (Vatn 2010, Muradian and Rival 2012). For instance, the design of a PES should be in line with the extension of property rights establishment.

2.2 PES and governmental PES

Vatn (Vatn 2010) has defined governance as the establishment and change of institutional structures for the organization of natural resource usage. He identifies three main types of governance structures - hierarchies, markets, and community

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management - and emphasizes that most types operate together. Following Vatn's step, Matzdorf et al. (Matzdorf et al. 2013) developed a typology of PES governance which assesses the diverse types of PES governance structures, focusing on the government's key role as a legal driver of ES demand and/or as an ES buyer (Figure 2). This framework classifies PES schemes into four different governance models: user-and non-government financed payments, government-financed payments, compliant payments and compensation payments according to whether the state takes on one of these roles, both of these roles, or none, and thus yielding. Which type of PES governance might work better should be determined by the existing institutional settings in a given space and time.

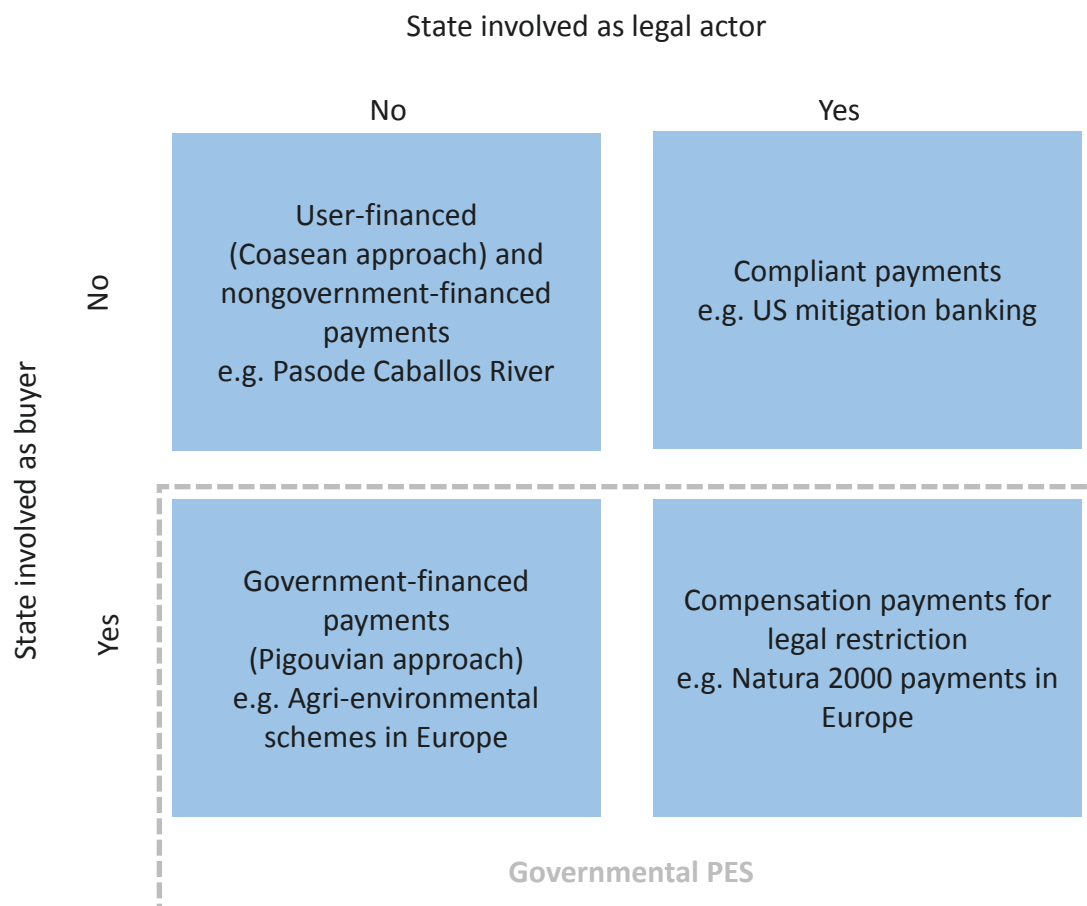


Figure 2: PES governance model (adapted from Matzdorf et al., 2013)

For my thesis, I have applied a broad definition of PES, and have assumed that governmental PES schemes include government-financed payments and compensation payments for legal restrictions (Matzdorf et al. 2013). For government-financed payments, the government acts as the buyer of ES but stays

out of legislations, such as agri-environmental measures (AEM) in Europe (Matzdorf and Meyer 2014), conservation programs in the US (Baylis et al. 2008), Payments for Environmental Services (PSA) in Costa Rica (Pagiola 2008), and Payments for Hydrological Environmental Services (PSAH) in Mexico (Kosoy et al. 2008). Another type of governmental PES is compensation payments for legal restrictions, where the state regulates institutions and compensates the fulfillment of regulations.

The majority of PES schemes comply with the Pigouvian conceptualization (Schomers and Matzdorf 2013) because governmental PES has great potential for achieving large-scale environmental effectiveness and poverty reduction when there is strong and sufficient state capacity (Engel et al. 2008). However, the pitfalls of governmental PES in terms of targeting, stakeholder participation, conditionality, and additionality have drawn some attention (Wunder et al. 2008). Indeed, the EU's agri-environmental policy (Baylis et al. 2008), Costa Rica's PAS (Pagiola 2008), Mexico's PSAH and Vietnam's Decision 380 (Suhardiman et al. 2013) have all been criticized for lacking in targeting and additionality. Besides this, bureaucratic implementation may endanger the stakeholders' voluntary incentives when their willingness is not fully respected (He and Lang 2015). Much literature on PES highlights challenges in the developing world, where property rights can often be incomplete (Bennett et al. 2011). The implementation of governmental PES in Vietnam (Kolinjivadi and Sunderland 2012), Cambodia (Clements et al. 2010) and Indonesia (Fauzi and Anna 2013) have been challenged for their lack of well-defined property rights. Moreover, the poorest households may be ignored or even excluded by centralized governance (Corbera et al. 2009).

2.3 Institutional context for PES in China

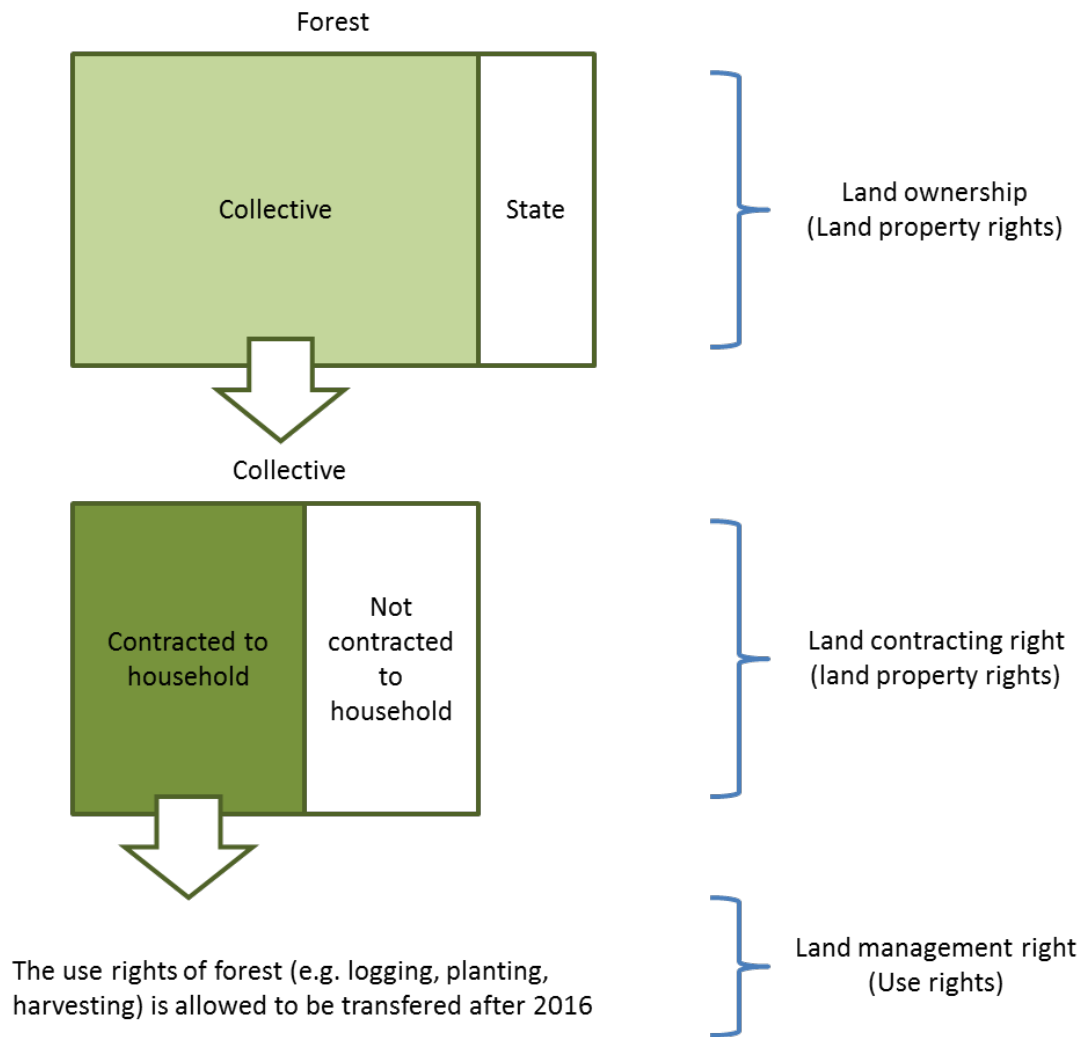
The provision of ES never takes place in an institutional vacuum, but has to build on the interplay of institutions, policy instruments and the property rights of the interconnected social and ecological systems. Legal institutions provide the basis for PES schemes and shape diverse features of PES schemes (Muradian and Rival 2012). In particular, the laws, legislations and relevant policies influence the design and operation of PES schemes (Vatn 2010).

No specific legislation exists for PES approaches or the similar Chinese term, eco-

compensation in China (Gaodi et al. 2015). Relevant laws and regulations are split across various policies formulated by different governmental departments and the State Council.

The government is the predominant stakeholder in China, as funding resources for ecological compensations have not expanded to non-government sectors in China. With the exception of transfer payments from central government, other channels, such as input by local government, enterprise and public institution, preferential credit and loan and social donations, are also absent (Gaodi et al. 2015). Some Chinese scholars have argued that government participation is necessary for eco-compensation in China, due to the income gap and beneficiaries' low willingness to pay (Shang et al. 2018).

Property rights in China have collective characteristics, as natural resources belong to the nation or are collectively owned by communities. In 1993, China started to allocate forestland use rights from village collectives back to households, either individually or in small groups, leading to a relatively clearly-defined and better-aligned property rights system. Property rights are closely related to land use rights (land contracting rights) and the right to commercialized services generated from land resources (land management rights) (Zhen and Zhang 2011). Households were given contracting rights and management rights for up to 70 years. In 2016, a remarkable reform divided traditional land rights into three separate rights: collective land ownership (土地集体所有权), land contracting rights for rural households (农户承包权), and land management rights (土地经营权) (Instrumentalities of the State Council 2016) (Figure 3). Before the reform, land contracting rights and land management rights were used in combination, so that households were not allowed to "sell" their land. After the reform, households will now be able to "transfer" land management rights while holding land contracting rights. However, this separation may cause some difficulty in defining exactly who is obliged to look after conservation (Uchida, Xu et al. 2005).



In China, land rights are separated into three different rights. Most forest is owned by collectives. But most collectively-owned forests are allocated to households as land contracting rights and land management rights

Figure 3: The separation of rights in rural land ownership system

Large-scale governmental PES programs have frequently been criticized for low levels of cost-effectiveness and environmental effectiveness. Low levels of cost-effectiveness are often the result of high transaction costs. Many studies have argued that intermediaries within governmental PES governance structures can play important roles in facilitating transactions between governmental buyers and private sellers (Schomers, Sattler et al. 2015). Therefore, involvement from intermediaries is considered helpful in reducing public and private transaction costs. Ideally, there are three intermediaries that might interact with a PES transaction: non-governmental organizations (NGOs), private consultancies and governmental entities (Schomers et al. 2015). However, China does not have a very long history of participating with

environmental NGOs and other social organizations for environmental interests. Western environmental movements are not the main driving force for ecological policy in China (Guttman et al. 2018). In particular, the environmental ‘civil society’ sector is dominated by government-related institutes and associations, such as the Beijing Environmental Protection Organization and China Environment Fund (Mol and Carter 2006). These government-related “NGOs” are far from independent to the government and have only played a relatively marginal role in in local rural areas. Therefore, intermediaries from civil society (western-style environmental NGOs, community groups and private consultancies) are not in place for ecological improvement in China.

The rapid urbanization process in China has also affected ecological conservation programs. Economic growth has changed the livelihood of rural households and drove migration from rural to urban areas. As a result, fewer people live in rural areas and fewer people will engage in farm-related activities. New institutional arrangements are needed to ensure land-based ES provision in the absence of the households which have migrated (Pan et al. 2017). Besides this, the change in labor markets can alter opportunity cost for land usage and influence incentives for household participation.

In summary, in lacking of non-governmental funding resources, clear property rights competitive market and intermediaries from civil society, the institutional context in China is incomplete for an ideal market-based PES. However, governance of ES needs to deal with broad ES, tens of millions of households as participant and poverty issues.

2.4 Governmental PES in China

In response to the enormous environmental challenges of land degradation, soil erosion, desertification, biodiversity loss and water pollution, China’s central government has launched a series of eco-compensation programmes to restore degraded ES, covering watershed ecosystem services, carbon, timber, landscape amenities, biodiversity conservation and anti-desertification services. The major programmes include Sloping Land Conversion Program (SLCP), the Natural Forest Protection Program (NFPP) and the Desertification Combating Program around

Beijing and Tianjing (DCBT) (Yin et al. 2010, Zhen and Zhang 2011). As a flagship toward an incentive approach, SCLP represents a hybrid governance type that includes both voluntary and hierarchical (top-down) elements (Bennett 2008). SLCP is considered a milestone in China's ecological policy and a growing body of literature views the SLCP as one of the world's largest PES programs (Yin et al. 2014). The official SLCP plan indicates that a wide array of ES are being targeted, including soil conservation, watershed protection, forest rehabilitation and landscape restoration (State Forest Administration 2003). Following the SLCP, numbers of PES-like programs have been implemented, covering forests, grassland, watersheds, wetlands, arable land and even deserts. Regardless of the different targeting of ES, the major PES schemes in China have inherited the logic of SLCP, which encourages governments on behalf of beneficiaries (Pan et al. 2017). Most of them are on large spatial and long temporal scales (Zhen and Zhang 2011).

Officially, the SLCP has an explicit emphasis on voluntary participation and local autonomy, which allows enrolled households to be free to take a contract or not (State Forest Administration 2007). Embracing innovative PES elements, the SLCP contains the key characteristics of payments for ecosystem services (PES) (Wunder 2015), as the central government payment to voluntary participants for land conversion. The implementation depends on household and village community willingness to accept the terms. The SLCP also contains components from the traditional command-and-control approach, such as top-down structure, inflexible contract design and campaign-style mobilization (Kolinjivadi and Sunderland 2012). The government sets the rules for participation and the implementation relies on hierarchically (top-down) structured governmental agencies at central, prefecture, county, and township levels (Bennett 2008). However, where to place SLCP and Eco-compensation in the governance model developed (Matzdorf et al. 2013) is still unknown.

In terms of policy design, as the department in charge of the SLCP in the central government, the State Forest Administration (SFA, following a wider national institution reform in 2018, the name was changed to State Forestry and Grassland Administration) created the overall plan and budget for the entire country, assigning reforestation tasks and payment to provincial governments by signing liability

agreements in which the liability is extended to counties, townships and, finally, participating households (The State Council 2002) (Figure 4). The plan for the following year evolved in the opposite fashion, from bottom to top, through an application system. Village and township governments submitted their proposed afforestation plans to each higher layer of government. In the end, the central government reviewed their plans and their achievements from the previous year and then partially or completely approved their plans (The State Council 2002). Ultimately, quotas were again allocated top-down through the administrative ladder. The government has the dual role of “buyer” and intermediary, which may encourage principal-agent conflicts and rent-seeking behavior.

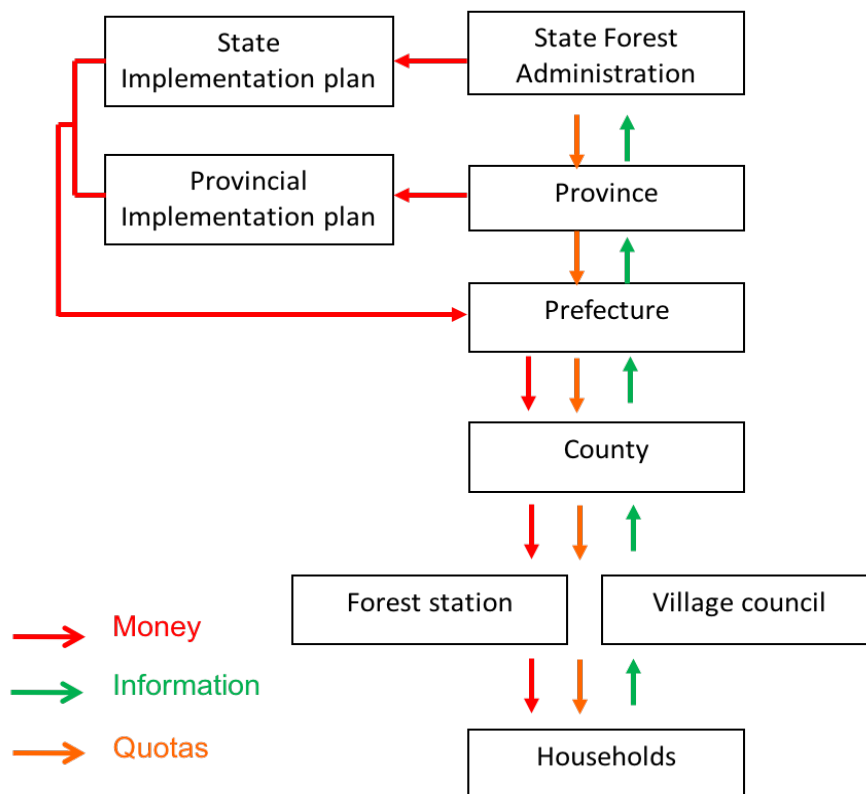


Figure 4: Administrative ladder and working flow of SLCP

Although complete ownership rights for natural resources and land belong to the collective or the state, SCLP is provided for contracting and management rights during the period of the SLCP contract only, rather than permanent ownership rights to the land (The State Council 2002). According to this policy of ‘whoever plants maintains and benefits,’ households are allowed to manage and benefit from the

products and services on their enrolled land (The State Council 2002).

In terms of policy implementation, SLCP permits households the right to determine some dimensions of their participation. At the same time, some command-and-control elements appear to be necessary to target the enrolled areas, determine the participants, distribute payments, provide technical support and monitor the program's success (The State Council 2002).

3 Framing Research on Governmental PES

3.1 Theoretical framework

I will view governmental PES frameworks through the lens of institutional analysis. Institutions are understood as the formal and informal rules that guide human interactions, from facilitating coordination to conflict resolution (Vatn 2010). PES have been conceptualized as new instruments designed to enhance or change behavior in relation to ecosystem management, through the provision of economic incentives (Corbera et al. 2009). The framework presented below builds on a conceptual approach previously developed by Corbera and Brown (Corbera et al. 2009), and can appear as a conceptual map for guiding institutional research on governmental PES.

3.2 Solidifying the research objectives

3.2.1 Institutional design

Institutional performance identifies whether an institution contributes to achieving a specific goal (Mitchell 2008). In other words, institutional performance analyses the contribution of PES to ES provision. Young (Young 2002) sees institutional design as something which is particularly constrained by limitations in the human ability to foresee institutional performance in complex systems. Most institutional arrangements are designed to meet a goal, “the solution of more or less well-defined problems” (Young 2002). Due to the diversity present in socio-ecological systems, a set of institutional designs works better under the given circumstances than one single institutional design (Ostrom 2008). Therefore, I have refined objectives A into three questions:

A 1: How are institutional settings correlated with the performance of a governmental PES?

A 2: How do institutional and socio-economic conditions influence local ES providers in reaching the provisions of ES under a governmental PES?

A 3: How can local actors influence the implementation of governmental PES?

Evaluating institutional performance requires the definition of criteria against which the institution in question can be evaluated (Corbera et al. 2009). My study on

governmental PES is rooted in the Chinese context, particularly the SLCP program. To identify the criteria of effectiveness and institutional, I have refined objective A 1 into two questions.

A 1.1: What are the institutional challenges of SLCP?

A 1.2: What is the relationship between effectiveness and institutional settings?

Because households have great importance in the implementation of SLCP (Liang, Li et al. 2012, Li, Bennett et al. 2017), understanding the linkage of institutional conditions and the program-induced provision of ecosystem services at a household level is critical for ensuring the success of governmental PES. While most existing studies considered conditions individually and independently, Meyer et al. (Meyer et al. 2015) first showed that the combination of certain design rules conditioned the success of a governmental payment scheme in Germany. In order to understand the combination effect of conditions on PES program design, I have refined objective A2 into two questions:

A 2.1: What are the necessary and sufficient institutional and socioeconomic conditions for a successful SLCP implementation at the household level?

A 2.2: What are the necessary and sufficient institutional and socioeconomic conditions for a failed SLCP implementation at the household level?

While the Chinese central government has formal authority over the design of eco-compensation, the implementation has largely relied on local actors. However, the program required a few modifications to become adapted to the somewhat varied ecological and economic conditions across the country, leaving a significant gap between the centrally designed policy and local situations for implementation. As farmers were offered payments for financial incentive, local agencies were over-dependent on bureaucratic incentives, such as promotion and administrative punishment. Local agents' demands for financial compensation and their ability for adaptation seemed to have been underestimated (Yu 2016). These deviations undermine the innovative elements of local engagement and willingness for PES, meaning there is risk of reversal to the governmental PES, turning it back into a compensation program. I have refined objective A3 to:

A 3.1: Which roles do the local agencies and households play in shifting a compensation program to a governmental PES?

3.2.2 Methods for ecosystem service governance analysis

Following a definition from Rival and Muradian (Rival and Muradian 2013), ecosystem service governance is ‘the institutionalization of mechanisms for collective decision-making and collective action with respect to natural resources management’. It has gained increasing popularity with the mainstreaming of the ES concept (Sattler et al. 2018). Corbera et al. (Corbera et al. 2009) view this question as one which concerns whether PES influences or is influenced by other institutions and which types of synergies or conflicts exist.

As one of the key challenges of ecosystem services governance, the analysis of institutional interplay is especially useful when learning about the interactions between different institutions and actors, and how institutional settings are correlated with the effectiveness of a PES scheme. In particular, institutional interplay concerns how a set of institutions affect one another, something which cuts across institutional design and performance (Young 2002). The principal assumption of this concept is that an interaction between two or more institutions can influence their respective outcomes. However, most analyses of institutional interplay were based on qualitative approaches, such as bibliographical review, stakeholder interviews and expert interviews. Methods which underpin a deeper understanding of ecosystem service governance in the context of interconnected social ecological-systems are just beginning to be explored and assessed (Sattler et al. 2018). In order to formulate a methodological contribution to the analysis of ecosystem services governance, I have refined objective B into two questions.

I propose using the Qualitative Comparative Analysis (QCA) to exam the institutional arrangement among several possibilities and the Social Network Analysis to explore the governance structure. For the first method, I drew on one governmental PES in China and one governmental PES in Germany to determine the possible range of application. With regards to the second method, the research tool was applied in four different countries and continents. I have documented the strengths and weaknesses of the proposed method against an international background, proposing ideas for improvements and further research.

I have refined objective B into B1 and B2:

B 1: How should the QCA be applied to support Comparative Institutional Analysis, and to determine the preferred institutional arrangements among several possibilities?

B 2: What are the strengths and weaknesses of using the Net-Map tool for participatory social network analysis in ecosystem service governance?

In summary, the contributions of each paper to the research objectives are outlined in figure 5.

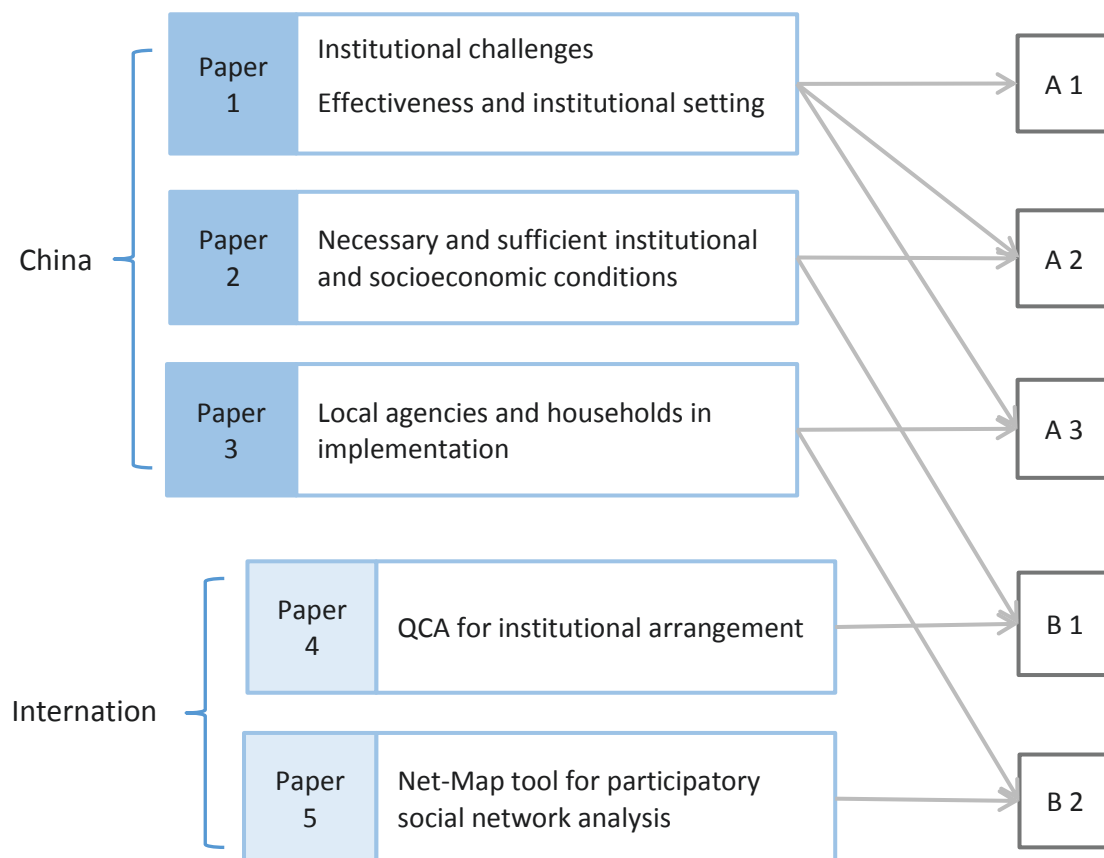


Figure 5: The contributions to research objectives

4 Publications

Paper 1:

The Institutional challenges of Payment for Ecosystem Service Program in China: A review of the effectiveness and implementation of Sloping Land Conversion Program

Paper 2:

How socioeconomic and institutional conditions at the household level shape the environmental effectiveness of governmental payments for ecosystem services program

Paper 3:

The network of actors in a governmental PES program: Local governance models for China's Sloping Land Conversion Program

Paper 4:

Qualitative comparative institutional analysis of environmental governance: Implications from research on payments for ecosystem services

Paper 5:

Strengths and weaknesses of the Net-Map tool for participatory social network analysis in resource management: Experience from case studies conducted on four continents

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Review

The Institutional Challenges of Payment for Ecosystem Service Program in China: A Review of the Effectiveness and Implementation of Sloping Land Conversion Program

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Abstract: This study is an overview of the effectiveness and institutional challenges of China's Sloping Land Conversion Program (SLCP). The SLCP is the Chinese government's largest Payment for Ecosystem Services (PES) program and one of the largest PES programs in the world. From an institutional perspective, the SLCP is particularly interesting because it represents a hybrid governance type that includes both voluntary and hierarchical (top-down) elements rather than traditional command-and-control approach. Our analysis is based on a literature review that encompasses 164 international scientific articles. To identify institutional challenges, we linked the results regarding the effectiveness of the program to its institutional aspects. Our SLCP case study highlights the dependence of the effectiveness of a governmental PES program on the specific regulatory institutional setting and the particular actors involved. Our results show that some institutional challenges undermine the anticipated advantages of PES (local participation) and eventually reshape the program outcomes through implementation process, particularly in cases of hybrid governance structures in which institutional requirements are as important as the design of the specific financial incentives. The collaboration between relevant government actors at different hierarchical levels, and specifically the motivations and interests of the government actors

responsible for the implementation on the ground, play crucial roles. The SLCP can be an important milestone in environmental policy in China and the world, if more innovative elements of a theoretically ideal PES—such as local flexibility and self-interest (or at least the acceptance of the service providers supplying the relevant ecosystem services) can be strengthened. The environmental goals can be achieved in combination with greater self-interest of the applicable government actors on all hierarchical levels.

Keywords: grain for green program; land set-aside program; effectiveness of implementation; hybrid governance; PES; sustainability

1. Introduction

Payments for Ecosystem Services (PES) are an increasingly popular way to manage ecosystems [1]. In addition to using market forces for the efficient allocation of user rights to natural resources, the “...PES philosophy argues for the internalization of environmental externalities through the creation of markets and quasi-markets” [2]. This notion is linked to the Coase Theorem [3], which holds that the problem of external effects can be overcome under certain conditions through private negotiations between affected parties. However, Coase negotiations do not represent the ideal market situation for the environment [4]. In accordance with this understanding, within PES schemes, people do not buy and sell ecosystem services (ES), as some authors argue [5], but instead buy and sell bundles of use rights over ES [6].

In both practice and research [7], the concept of PES has been broadened to include government payments, which function as a PES-like mechanism [8]. This broad concept of PES is consistent with the Pigouvian approach [7], through which government either pays itself or makes others pay on behalf of beneficiaries [6,9]. The term PES is used as a broad umbrella [10] term for any type of conservation instruments that employ positive financial incentives. The governance model beyond the pure market-based PES system is often a hybrid type in the sense of Vatn [11]. The state represents an important actor not only as a financier but also as a legal driver [9]. Consequently, the effectiveness and efficiency of PES schemes depend on the interplay of all the institutions and actors involved. The actors are frequently connected by more than purely economic relationships [11].

The advantage of PES schemes over conventional command-and-control measures is based on the argument that social negotiations and voluntary approaches perform better in terms of cost-efficiency and local acceptance, in particular. This fact must be considered when PES systems are discussed as an innovative conservation approach that supports proactive action, replication, and stakeholder participation, that spurs competition, and that produces new sources of funding and positive side-effects [12]. Thus, on the one hand, if command-and-control institutions dominate all of PES governance, these advantages can be limited. On the other hand, there are good arguments that hybrid institutions, including command-and-control approaches, are frequently the most appropriate to consider in complex social-ecological systems [13].

The analysis of this type of hybrid governance PES approach seems most useful in learning about the interaction of different institutions and actors and how the institutional setting is correlated with the

effectiveness of a PES scheme. China has one of the world's largest hybrid governmental PES programs. With its rapid economic growth over the past three decades, China's environmental degradation has also accelerated [14]. These problems have included land degradation, soil erosion, desertification, biodiversity loss, water pollution and water shortages [15]. In response to these enormous environmental challenges, China's central government launched a series of programs aimed at ecological restoration and ecosystem conservation with payment from the government in the late 1990s, and these programs are most commonly categorized under the domestic term eco-compensation [16]. This institutional arrangement was perceived as protecting and sustainably using ecosystem services to adjust the distribution of costs and benefits between different actors and stakeholders, primarily through economic measures [17]. Although the terms "eco-compensation" and "PES" are often used interchangeably [18], eco-compensation is a broader term that encompasses PES-like policies that involve direct payment by the government to individuals and community-level suppliers under market mechanisms [19], in addition to a range of other policy and program types. According to this classification, there are 24 major PES-like programs in China (see Supplementary Material 1). The targets of them range from watershed protection and soil erosion control to carbon emissions control and eco-agriculture [18]. As a typical government-financed ecological restoration program, the "Sloping Land Conversion Program" (SLCP)—also known as the "Conversion of Cropland to Forests Program" or "Grain-for-Green"—is considered one of the largest PES programs in the world [20], and its broad geographic cover [21], wide participation [22], tremendous investment [23] and institutional innovation [24] have drawn significant attention from the scientific community. This program was launched in 1999 with the goal of increasing forest cover and preventing soil erosion by converting sloping farmland into forests or grassland [25]. Consistent with PES's stated principals of volunteerism and local participation [26], the SLCP uses a public payment scheme that directly engages millions of rural households as core agents of project implementation [26]. Although there are different classifications, the SLCP is considered a PES program by a number of researchers [19,24,27].

One of the main challenges linked to PES development is the appropriate consideration of a variety of social-ecological systems, and its applicability often depends on complex institutional settings [11]. A number of studies individually assess the SLCP from mainly environmental [28], socioeconomic [29] and institutional perspectives [30], and utilize many different elements and indicators. Few studies have investigated the various situations and multiple dimensions of the SLCP, with the exception of a series of papers published by Yin *et al.* [31–35]. By reviewing the program in terms of its implementation efficacy, socioeconomic effects and environmental impact, Yin *et al.* [31] developed an integrated assessment and called for more attention to program execution and interdisciplinary research. In another article, Yin *et al.* [34] assessed the program's outcomes by exploring the governance of the SLCP, claiming that certain contexts under the label of "implementation" appear to be challenges to the program. Asking further questions about how to design an effective PES program, Yin *et al.* [35] examined the SLCP under the diagnostic framework of a social-ecological system with analyses from ecological, socioeconomic and institutional perspectives. However, Yin *et al.* [33] considered the SLCP one of the ecological restoration programs (ERP) in China and always took ERP, rather than the SLCP, as the research target. Particularly, whether the SLCP has been implemented effectively; how governance and policy implementation affect program outcomes; and how its performance can be improved are still not clear [30]. As suggested by He *et al.* [36], to understand the driving forces of the

effect of the SLCP, efforts to contextualize the social-ecological interaction in the broader system of institutional economy are needed.

In this review, we focus on how the effectiveness of the SLCP is influenced by many design and execution contexts that fall primarily under the institutional umbrella. The primary goal of this article is to provide a literature survey on the SLCP with multiple dimensions and, in the end, to link the deviation between effectiveness criteria and program outcomes with their institutional contexts. To do so, we first gather the literature with a keyword-based web search and follow the classification from Yin *et al.* [32]. We sort the literature according to different indicators from environmental, socioeconomic and institutional perspectives. After an overview of research topics covered in the previous SLCP literature, our next step is to build criteria from the literature for program effectiveness. The actual “effectiveness” of an environmentally targeted conservation policy is complex and difficult to assess. There are different frameworks to measure effectiveness, such as the capital asset framework (CAF) [37] or the social-ecological system [38], and they are frequently built on a longer-term basis [34]. Here, we adapt the method from Yin *et al.* [39] and analyze the effectiveness from two determining positions: effective implementation and program impacts. Elements relating to implementation, such as converted areas, the survival rate and restored vegetation, can be categorized as effective implementation. Accordingly, the socioeconomic impact (e.g., change in income, labor transfer) and environmental impact (e.g., erosion control, water conservation) can be categorized as program impact. In our article, effectiveness is ultimately gauged based on effective implementation, socioeconomic impact and environmental impact. Nevertheless, the effectiveness criteria cannot always match program outcomes. Therefore, our third step is to summarize the previous findings on the deviation between effectiveness criteria and program outcomes. Fourth, we identify institutional challenges. Finally, to answer the question of how to improve the performance of the SLCP from an institutional perspective, we discuss the dependence of the identified deviation on these institutional challenges. The results of this study can help support the development and improvement of government-financed PES in China and throughout the world. Our analytical structure is shown in Figure 1.

The remainder of this paper is organized as follows. Section 2 describes the SLCP and how it is implemented. Section 3 presents an overview of the SLCP literature, focusing on current research priorities. Section 4 identifies the effectiveness criteria used in the literature, analyzes the deviation between the criteria and outcomes and summarizes the relevant institutional challenges. Section 5 discusses the dependence of the program’s effectiveness criteria in an institutional setting under a hybrid governance regime. Section 6 concludes the paper.

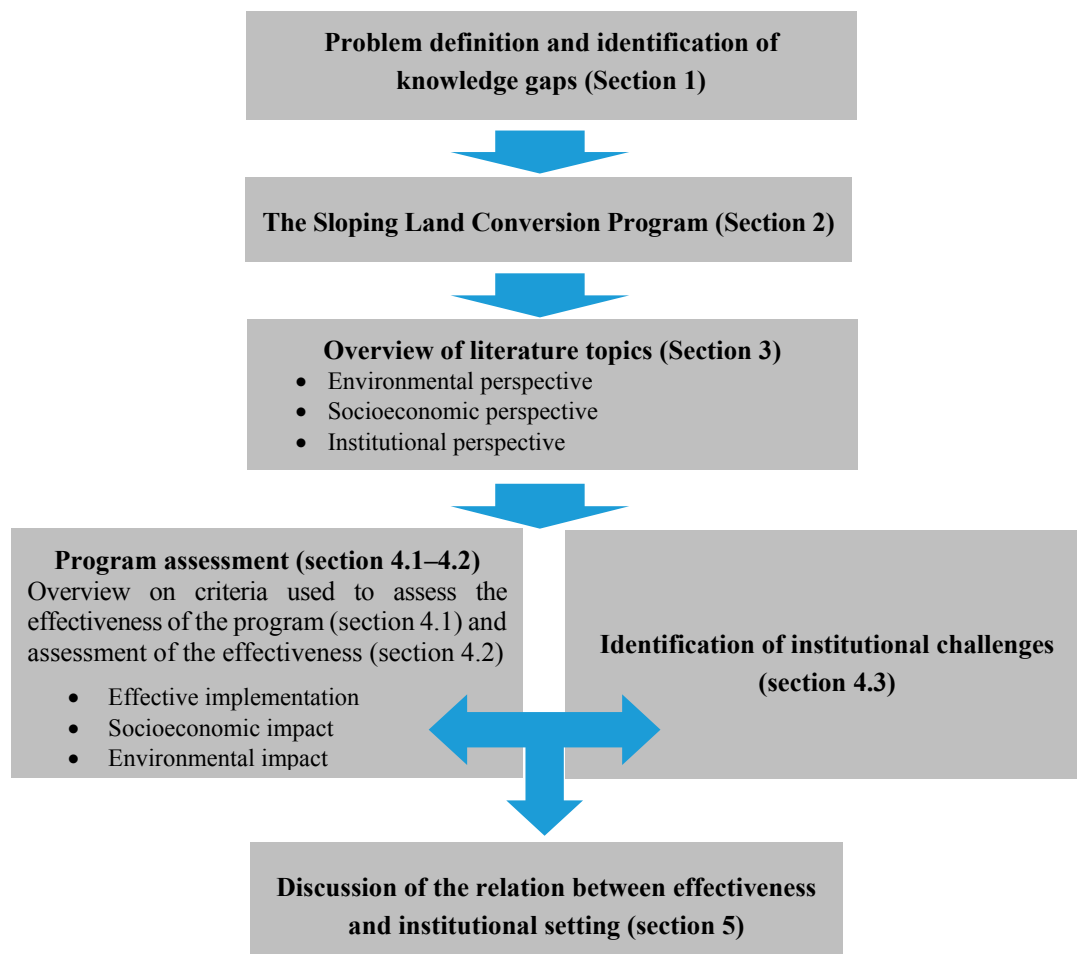


Figure 1. Analytical framework.

2. The SLCP

The severe drought of the Yellow River region in 1997 and the widespread flood of the Yangtze River in 1998 spurred the Chinese government to take action in response to the growing degradation of the country's forest ecosystem [24,40]. Under these circumstances, the SLCP aims to increase the country's forest and grassland cover and to reduce soil erosion, flooding, desertification and other ecological disasters [23] by retiring steeply sloping land (greater than 25 degrees) from agricultural use and returning it to forest and grassland [41]. After a pilot phase from 1999 to 2001 in three provinces, the SLCP was extended to 25 provinces. The program involved over 32 million rural households, and 257.22 billion RMB had been spent by 2010 [42]. The official goal of the SLCP was to convert approximately 14.67 million hectares of cropland to forest (4.4 million of which is on land with a slope greater than 25°), afforest 17.33 million hectares of wasteland and increase the forest cover in the enrolled area by 4.5% by 2010 [43]. Upon full implementation in 2002, the converted land jumped from 0.39 million hectares to 2.04 million, more than a fivefold increase [42]. As shown in Figure 2, after reaching its peak in 2003, new program enrollments began to decrease rapidly and almost completely

stopped in 2007 because the central government stopped assigning liability to lower-level government in 2006. The tasks of the program thus became to consolidate the achievement on former cropland and to continue afforestation on wasteland and barren mountains [43]. By 2012, 8.0 million hectares of cropland had been retired and converted under the SLCP, which was less than 60% of its original target; the program had also established forests elsewhere on another 16.29 million hectares. Obviously, the original target for cropland retirement has not been achieved.

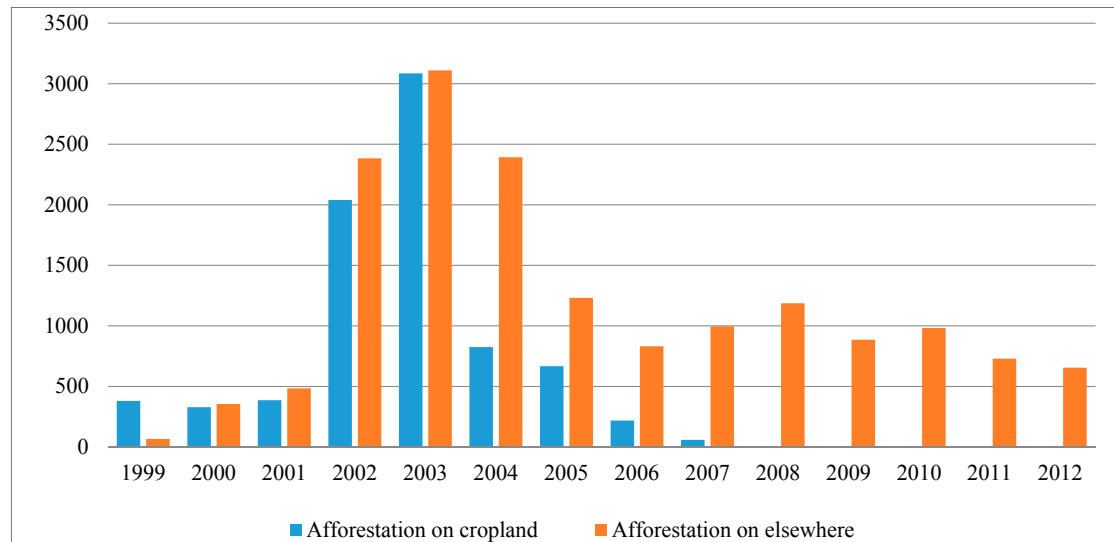


Figure 2. The Sloping Land Conversion Program implementation (unit: 1000 hectares).
Source: China Forestry Statistic Yearbook 2012 [42].

The two objectives of the SLCP are to restore the nation's forests and grasslands to prevent soil erosion and to alleviate poverty in some of China's poorest regions [41]. The main instrument of the SLCP is direct compensation of households in cash, grain, or seedlings for trees by the central government. Compensation varies based on two geographical differences. Compensation in the Yangtze River Basin is higher than in the Yellow River Basin, which is in accordance with the opportunity costs of local cropland plots [31]. The period of compensation differs based on the type of conversion taking place. Households can choose either an "economic forest" (*i.e.*, forests that produce timber, fruits, nuts, medical goods, and other commodities), an "ecological forest" (*i.e.*, forests that provide primarily ecological functions and services) or grasslands, for periods of five years, eight years or two years, respectively [31]. However, in reality, most of the retired cropland has been planted with trees of mixed species and enrolled for eight years [23]. In 2004, the State Council issued standards for converting grain to cash at the rate of 1.4 RMB/kg because of dwindling public grain reserves [34]. In 2007, most contracts were supposed to end. To sustain the livelihood of participants, the State Council decided to extend the program for another round (2–8 years); however, the subsidy has been halved [44].

In the official annual reports, the most common indicators used to evaluate the outcomes are the enrolled area, the tree survival rate and the program acceptance rate after inspection [43]. The program is conditional in terms of land retirement but less so in terms of management of trees and grass

established on the enrolled land, let alone the ultimate services that the restored ecosystems provide, such as erosion control and runoff regulation [33]. It is a typical “input-based PES program” in that payments are frequently made on a per-hectare basis. The SLCP’s conditionality is high for retired areas and lower for successful forest plantations, which departs from the classic pattern [27].

The original institutional framework was simple: The central government provides compensation to voluntary participants for land conversion, which is presumed to improve the provision of ecosystem services in the future. This innovative feature is why the SLCP differs from most other nature conservation programs in China. It first combines a large-scale government program with direct engagement by voluntary households and village communities using financial incentives [24]. Thus, on the one hand, the government sets the rules for participation and other types of institutions, including the amount of the payment. On the other hand, implementation theoretically depends on household and village community willingness to accept the terms. This key rationale reflects the defining principle of PES, *i.e.*, a voluntary transaction in which a land use that is likely to secure the ecosystem service is “bought” by at least one service buyer that engages with many providers [8]. By contrast, many studies have observed that because the government is the only service buyer, this type of hybrid program is typically less voluntary for the provider compared with purely market-based programs [27].

The program’s design is innovative, but because implementation relies on government agencies, the SLCP remains hierarchically (top-down) structured. This type of PES can thus be characterized as hybrid governance [6]. In the implementation process, as the department in charge of the SLCP in the central government, the State Forest Administration (SFA) created the overall tasks for the entire country and assigned reforestation tasks to provincial governments by signing liability agreements [41]. The targeting of areas to retire has generally been performed via a top-down approach, beginning with retirement quotas that are distributed by the central government to the provinces and continuing on to counties, townships and, finally, participating households [45]. The onus of actual implementation has thus fallen on townships and village governments [33]. The local agencies allocate quotas, target the enrolled areas, determine the participants, distribute payments, provide technical support and monitor the program’s achievements [41]. The plan for the following year evolved in the opposite fashion, from bottom to top, through an application system. Village and township governments submitted their proposed afforestation plans to each higher layer of government. In the end, the central government reviewed their plans and their achievements from the previous year and then partially or completely approved their plans [41]. Ultimately, quotas were again allocated top-down through the administrative ladder.

3. Overall Literature Analyses

3.1. Dataset Establishment

The literature search for this study was conducted in July 2014 and updated until December 2014. All names of the program (“Sloping Land Conversion Program”, “Grain for Green Program China”, “Conversion Cropland to Forest and Grassland Program” and “Payment for ecosystem service China”) were used as keywords to search the Web of Science and the Scopus database (1999–present). No other search terms were considered because the dataset was designed to present the overall picture of the SLCP study. After careful selection, two-thirds of the reference materials unrelated to the topic of this study were excluded. Additionally, for discussion purposes, we included highly relevant literature that could

not be found with the above strategy by pursuing the references in the literature that we had found. Ultimately, we obtained 164 journal papers covering all the study subjects (see Supplementary Material 2). The following analysis and results are based on this dataset. We acknowledge that many more studies have been published in domestic Chinese journals. However, because these studies were not written in English and most are not peer-reviewed [31], we did not include them in our dataset. It is notable that our literature search was based on defined keywords and therefore some relevant articles might have been overlooked. However, to minimize this possible bias, we carefully searched for relevant references in the available literature.

3.2. Literature Sorting

First, the 164 articles were sorted according to their main research topics. It should be noted that many papers address more than one topic; thus, each paper can have a maximum of three topics, although only the most important topic is considered the representative topic. Therefore, we defined the representative topic as the single topic criterion and other less important topics as multiple topic criteria. The papers were then classified into different subject categories according to their single and multiple topics. As an environmental policy, the goal of the SLCP covers many aspects, and the single and multiple criteria can be used as the indicator for comprehensive evaluation. By making this comparison, we can better understand the interdisciplinary research of the SLCP and identify the relationships among the different subjects.

After carefully reading, we selected 26 topics (detail in Figure 3) with environmental, economic, social and institutional aspects to classify our dataset. There are 13 topics related to the environment aspect, five topics related to economics aspects, five topics related to social aspects and three topics related to institutional aspects. Integrated studies and comparison studies are hard to classify, so we list them as other. Again, we acknowledge that there may be potential bias or overlapping of this classification, although we carefully select them to represent the available literature.

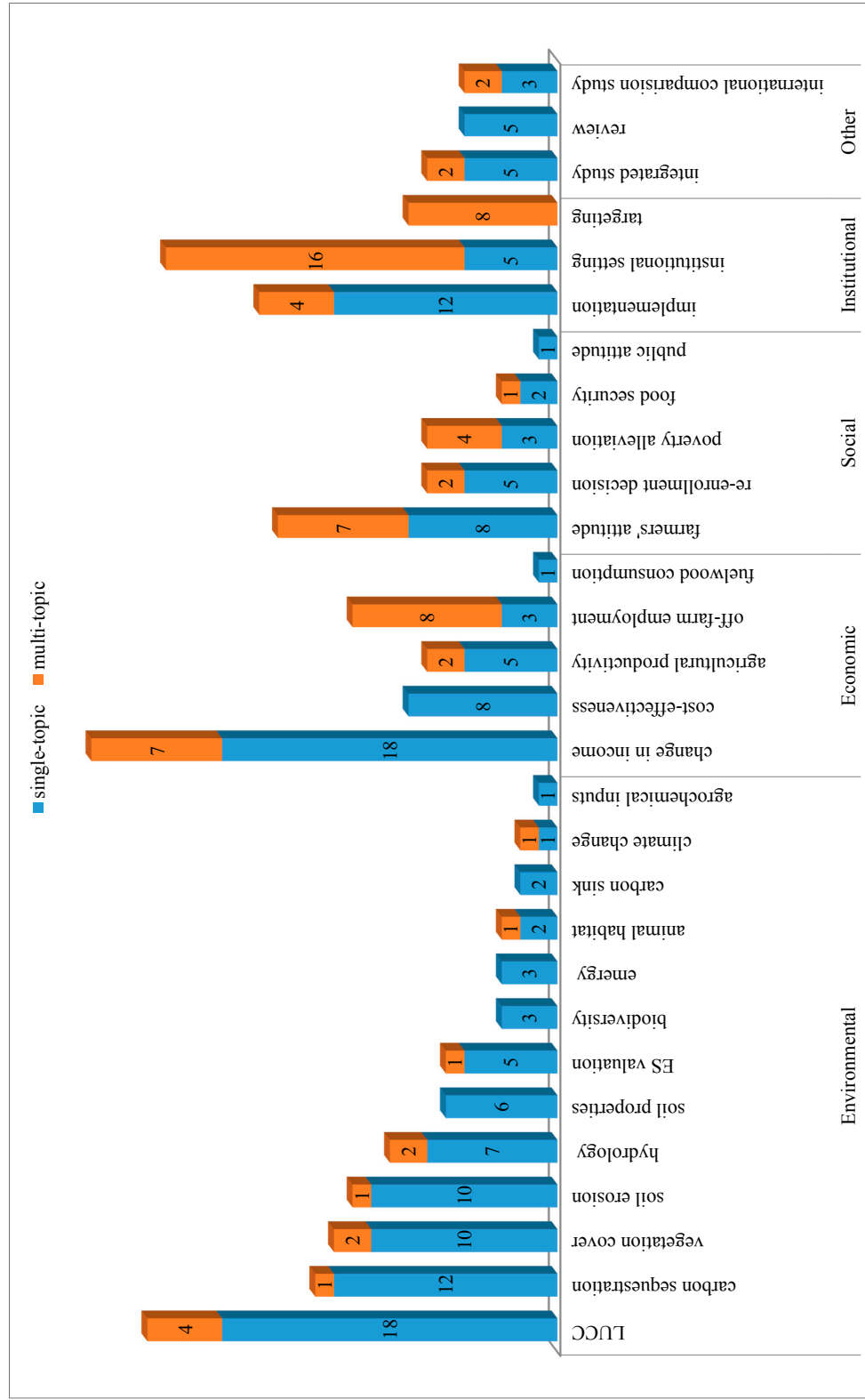


Figure 3. A classification of the literature according to research topics.

3.3. Research Area

To understand the literature on the SLCP, we established environmental, social, economic, and institutional subject areas based on their single main topics. As a consequence, we obtained a result such as that shown in Figure 4.

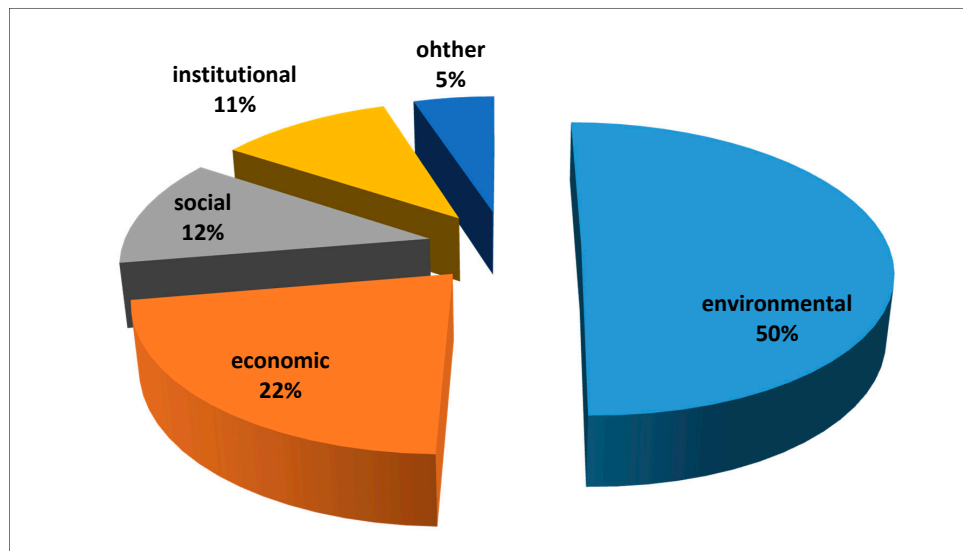


Figure 4. The subject areas of selected studies (n = 164).

Remarkably, half of all the published articles in international journals regarding the SLCP refer to environmental aspects. Economic aspects, social aspects, and institutional aspects are the focuses of 22%, 12% and 11% of the articles, respectively. Thus, the institutional aspect has drawn the least concern from the scientific community. When we examine the details, 17 articles refer to institutional studies, including 12 articles about implementation and five about institutional settings. Among these, five were contributed by a team [46] that included Michael Bennett, Zhigang Xu and Jintao Xu (as colleagues and co-authors), and their main interests were policy formulation and top-down approach implementation. Another team at Michigan State University led by Runsheng Yin [23] published four articles concerning implementation strategy, whereas other articles explored the governance of policy implementation [30], notions of justice [47], trust and property security [48], and local variations in implementation [49].

3.4. Single and Multiple Topics

In this section, we seek to compare the results of different paper classification methods to identify how the different aspects relate to one another (Figure 3). In the single topic criteria, changes in income (18 articles) and implementation (12 articles) drew considerable attention. Although environmental studies constituted 50% of all the research, those articles' topics are broad and scattered. There are 14 topics related to environmental aspects, but only five related to economic aspects, five related to social aspects, and two related to institutional aspects. It is clear that most papers on environmental studies

focus on only one environmental topic, such as Land Use and Land Cover Change (LUCC), soil science, carbon sequestration or hydrology.

Including multiple topics as the criteria, the number of papers on the institutional setting increased rapidly from five to 21 and became the second most popular topic. Targeting and implementation also increased to eight and four papers, respectively. This growth made the institutional category grow from 17 papers to 45 papers. The growth came primarily from the contributions of the other three aspects. In the economic and social categories, the number of papers increased by 48.6% and 73.7%, respectively. However, the growth in the environmental category was only 16.3%. This result shows that, although most studies focus on environmental studies, institutional aspects connect wider research topics when we look at the big picture. This finding may demonstrate that the SLCP's institutional and socioeconomic aspects have many direct and indirect links with its outcomes and that these relationships are not independent. In fact, many economists and ecologists have found that the socioeconomic and environmental effects may have certain links to implementation strategies. For example, Gauvin *et al.* [50] suggested that the dual goals of the program design are a barrier to improving cost-effectiveness. Moreover, the ecologist Cao [51] asserted that unsuitable afforestation design seems likely to worsen local water shortages.

4. Results

4.1. What Criteria for the Program's Effectiveness are Described in the Literature?

4.1.1. Effective Implementation

4.1.1.1. Effectiveness of Targeting

According to official document [52], the principle of targeting is that “sloping land suffering from serious soil erosion and that is low-yield should be afforested as much as possible under the plan approved by State Council; while government cannot force households to retire land with good production conditions and high yield that is causing no soil erosion”. In other words, the targeting criteria are sloping and low-yield land. This official strategy is recognized by many researchers as a means through which the program achieves its goal of preventing soil erosion at the lowest possible cost [25,50,53]. For example, Uchida *et al.* [25] showed that targeting land on the basis of individual plot sizes, slopes and yield histories might maximize the environmental benefit and minimize payments. In the same vein, Gauvin *et al.* [50] further asserted that with the exception of land associated with high environmental benefits and lower opportunity costs, land managed by poorer households should have been considered. Additionally, Wang *et al.* [54] suggests that local heterogeneity must also be taken into account because local and regional biophysical and socioeconomic characteristics vary greatly based on the land's productivity and susceptibility to erosion.

4.1.1.2. Stakeholder Engagement

As an approach that is distinct from and innovative compared with conventional programs, the SLCP claims to be decentralized and voluntary [24]. It directly engages rural households with respect for local volunteerism and autonomy, abiding by the core principle of PES, which is defined by Wunder [8] as a

voluntary transaction. As noted in The Economics of Ecosystems and Biodiversity report [55], “wide participation in decisions relating to PES design and implementation can help ensure transparency and acceptance and to avoid the covert privatization of common resources”. Without adequate consultation and “bottom-up” initiatives, local people tend not to plant or properly maintain trees and grass [56], and as a result, survival and growth rates can be negatively affected [34,56].

4.1.1.3. Compliance

The aspect of “conditionality” is considered critical for PES because it ensures that participants actually comply with their contracts [8]. Regarding SLCP, the term of conditionality was replaced by program compliance to define the trees/grasses planted on the enrolled land in terms of their quality, types and survival rates [24]. Compliance includes two essential parts: monitoring and sanctions. Effective and lasting monitoring, particularly internal monitoring and enforcement, should be a major component of implementing any PES program [32]. During the pilot phase, the most important compliance condition is the tree survival rate, which was 85% for the Yangtze River Basin regions and 70% for the Yellow River Basin regions [24]. Later, this standard was revised to a nationwide standard of 75% for full-scale implementation [24].

4.1.2. Environmental Impact

The main environmental impact of SLCP is found in forest ecosystems. Some environmental effects are immediately observable, such as the amount of land converted and afforested and the changes in vegetative cover [57]. By contrast, effects on flood control, carbon sequestration, and climate change, for example, are to a large extent inferred from changes in immediately observable factors [21], which makes it difficult to directly attribute program effects.

First, vegetation cover was accorded great significance in consolidating the reforestation achievements and effectively controlling soil erosion. Various studies, such as those by Zhou *et al.* [58], have used vegetation cover to evaluate the success of the SLCP. Indeed, Zhou *et al.* [59] found that the reduction of soil erosion in the Loess Plateau was partly attributable to the increase in forest coverage induced by the SLCP. Second, the program is considered to improve the physical properties of the soil structure and reduce nutrient loss to maintain soil fertility, in addition to decreasing river sediments [60]. The effects of the changes in surface runoff and sediment yields have been widely studied [61]. Third, the SLCP provides a good opportunity to restore biodiversity regions that have been destroyed or dramatically affected by human activity [62]. Fourth, large-scale afforestation under the SLCP will result in an extensive new forest and hence enhance the carbon sequestration capacity of China’s terrestrial ecosystems [63].

4.1.3. Socioeconomic Impact

4.1.3.1. Income Improvement

A PES program can offer a means to increase the incomes of the rural poor and reduce risk by diversifying income sources, primarily through monetary payments [29]. Because most households in the target areas are poor and many are located on steeply sloped land, the program must be able to provide

livelihoods to ensure the participation of households affected by the program [64]. Uchida *et al.* [25] assert that payments to households for entering their plots into the SLCP largely exceed the plots' opportunity costs; as a result, the average participating household should be better off by participating.

In addition to direct compensation, the new planting of commercial forests (such as fruit orchards) will continue to increase participants' income, and the government-invested newly built infrastructure will either provide income (e.g., fish ponds, livestock-raising facilities) or reduce households' costs (e.g., methane generators) even after government subsidies end [64].

4.1.3.2. Labor Relocation

The rapid loss of cropland has provided an abundance of labor for other businesses, and households can choose to allocate their labor off the farm market [59]. For example, the average cropland area of participating households in Wuqi in Shannxi Province dropped to approximately 30% of the original area during the 2004–2010 period [65]. These changes suggest a significant decline in on-farm labor use, and households might thus have much to gain from reallocating the surplus labor to off-farm employment. To solve liquidity constraints, it is easier for participating households to switch to non-farming activities than it is for non-participants [66]. Furthermore, this transition from on-farm to off-farm labor allocation and the diversification of revenue sources are keys to ensuring that the converted land is not returned to cropland [67].

4.1.3.3. Poverty Alleviation

The land owners who provide these environmental services are predominantly poor; consequently, a well-designed program can contribute to alleviating poverty [29]. The SFA explicitly states that poverty alleviation and restructuring agricultural production into a more environmentally and economically sustainable set of activities are goals of the SLCP [26]. Moreover, compensation under the SLCP is higher than opportunity costs, and one explanation for setting this compensation level is to benefit poor households [25]. However, the opportunity costs of retiring cropland and the operational costs of restoration vary with farming practices and natural conditions [35]. Therefore, it is worthwhile to have competitive participation selection based on the opportunity costs of local conditions [35].

4.1.3.4. Sustainability of Forest

Some studies [25,51,68] suggest that the long-term effects and sustainability of the program are decided primarily by the households' behavior once payments cease. For example, Uchida [25] examined the issue of the sustainability of the SLCP through its potential to generate sufficient income that will continue after the formal program ends. In another example, Xu *et al.* [56] contended that the ultimate success of the SLCP depends on its ability to restructure the production practices of rural households so that they can increase the opportunity cost of their non-farm labor (e.g., livestock production and off-farm employment). To ensure the sustainability of forests, a sustainable livelihood should be guaranteed to the people losing their cropland.

4.2. Deviation between Effectiveness Criteria and Program Outcome

The official evaluation report [43] of the SLCP presents the remarkable accomplishments of the program at the national level. Our analysis shows the differences between the national perspective and regional/local implementation.

4.2.1. Effective Implementation

One interesting finding is that the SLCP's spatial targeting has not always been achieved. Studies by Uchida *et al.* [25] and Xu *et al.* [46], for example, have found that in some cases, productive, low-sloped parcels have been included in the program, whereas in other cases, less productive high-sloped parcels have not. Uchida *et al.* [25] indicate that cost-effectiveness may have been compromised in practice due to overly rapid expansion and conflicts with local government priorities. Based on studies in northeast China, Wang and Maclaren [69] concluded that the targeting process was generally inefficient because productivity and environmental heterogeneity were ignored. There were many critics of the inefficient top-down implementation approach [24,35] associated with quota systems [46,70], and most blamed the local government, which preferred the easier-to-implement method of simplifying the plots-based selection [45,71].

Many studies [24,70] criticize the level of stakeholder engagement. For example, a survey conducted in Shaanxi, Gansu and Sichuan provinces in 2003 showed that approximately 53% of households could choose whether to participate [24]. One survey in Hubei and Shanxi in 2011 showed that 86% of households participated in the program because they were required to do so by the government [72]. The most recent survey in 2014 in Yunnan found that only approximately 45% of households were consulted about their willingness to participate in the program [30]. In practice, this consultation is commonly carried out at a village meeting that merely served to distribute required participation information instead of being an actual consultation [30]. Worse, due to the rushed initiation, even local planners do not have the knowledge to fully engage, resulting in even more confusion for participating households [32]. Many findings confirm that for some areas, implementation of the program proceeded in traditional top-down fashion [24,32,45], without engaging households regarding their interest and willingness in participation [24,32], although the policy highlights the importance of local volunteerism [34,56]. Another critical point is that compliance has, to some extent, not been achieved. Compliance is monitored via a series of inspections conducted by various levels of government [24,71]. Because most enrolled land is in remote areas or in villages, village officials must check the land regularly. Furthermore, formal annual evaluations are conducted by township and county governments, and random but rare inspections are conducted by higher-level government entities or officials from the SFA [73]. According to the SFA, 97.4% of the enrolled land was monitored over the 1999–2005 period, and 93% of it was deemed to pass the acceptance inspection [74]. However, many research results contradict these official reports; Bennett [24] found that the survival rate was 75%, and Cao *et al.* [51] found that tree survival rates in the afforestation plots averaged only 55.7% in the first year after planting and 49% in the seventh year in northern Shaanxi Province. Similarly, the sanction mechanisms for non-compliance do not appear credible [24].

4.2.2. Environmental Impact

In addition to several studies [75,76] that highlight the positive environmental effects of the SLCP, other studies, such as Cao *et al.* [77] and König *et al.* [78], also note some challenges with regarding to afforestation. First, a crucial aspect noted in this regard is that afforestation with unsuitable species may damage local water balances, even exhausting limited ground water, and may result in dead or dying trees. The potential regional effect of afforestation on watershed hydrology and water-resource management has not been thoroughly investigated [79]. On the one hand, forest areas in China are considered to play an important role in water cycling and water conservation, particularly with respect to flood reduction [80]. However, after crop land is converted to grassland, it is assumed that the water budget will be substantially disturbed because of the significant changes in vegetation components and in the vegetation cover period [81]. On the other hand, serious water shortages become progressively more limiting for further vegetation establishment, particularly in semi-arid steppes, which could ultimately lead to increasing desertification, as is the case in areas of Northern China [51,77], such as the Loess Plateau. Second, monoculture plantations and exotic species can also reduce biodiversity when they replace natural ecosystems [82]. In fact, during planting, there was widespread destruction of natural vegetation, such as the removal of natural herbaceous vegetation (*i.e.*, grasses, forbs, herbs) to promote tree growth [51]. The monoculture plantations are also at high risk for insect and disease problems [83].

In this regard, Cao *et al.* [84] summarized the situation nicely, stating that the “huge investment to increase forest cover seems likely to exacerbate environmental degradation in environmentally fragile areas because it has ignored climate, pedological, hydrological, and landscape factors that would make a site unsuitable for afforestation”.

However, forest cover change cannot always be credited to afforestation programs [85]; state forest policies may have been the main driver in the past, but private afforestation activities increasingly dominate the expansion of tree cover [85]. He *et al.* [36] provide further evidence that the contribution of the SLCP to forest cover is conditional on the institutional setting.

4.2.3. Socioeconomic Impact

The effects of the SLCP on participants' livelihoods are diverse, as reflected by key indicators such as income change and labor transfer. In different regions of China, the outcomes strongly depend on the local contexts and conditions. In most study cases [65,86], the majority of households noted that the program actually increased their net incomes. Other studies, such as those by Song *et al.* [72] and Wang *et al.* [54], show that in some regions, households considered themselves to be worse off after participating in the SLCP. A longitudinal household study [23] doubted the efficiency of economic compensation because households received incomes that were either substantially higher or lower than their former crop incomes. In particular, it was noted that in the early implementation phase, compensation exceeds opportunity cost, and the program has received support from a large proportion of participants [25]. As time has passed, the prices of commodities have risen every year; however, the compensation standard is halved, making it a much smaller part of families' incomes. Consequently, it is reasonable for some households to have lost interest in the program and that some even want to return to farming. For example, in a survey conducted in 2005 in the Shaanxi Province, a large proportion

(37.2%) of participating households stated that they would return to cultivating forested areas and grassland once the project's subsidies end in 2018 [22]. In the province of Ningxia, only approximately 8% of households said that they would not re-convert their land to cropland following termination of the compensation [87].

In addition to compensation, income inequality [88] and the changes in income sources [47] induced by the SLCP have effects on income changes. By studying the Gini coefficient, Li *et al.* [88] found that income inequality is lower among participants than among non-participants. Xu *et al.* [89] also questioned the quality of development. Additionally, using the difference-in-differences model, Uchida *et al.* [25] found that the program has not induced significant changes in income sources except for the program payments. Using the same model, Yao *et al.* [90] showed that the income source does not significantly change apart from off-farm work, and the effect on crop production is not as negative as was once thought.

The argument of labor transfer has been studied intensively but remains unclear. Li *et al.* [88] found that the SLCP has not improved labor transfer to off-farm activities in the survey site because most participants still engage in traditional farming. By contrast, Yao *et al.* [90] showed that the program has accelerated the transfer of farming labor and has greatly stimulated income growth from off-farm opportunities. A 2003 study conducted by Uchida *et al.* [29] found no strong evidence that participants had changed their labor to off-farm work. Surprisingly, two years later, tracking the same group of households with the same method, researchers claimed that the program had significantly relaxed the liquidity constraints for participating households [66]. Other evidence also showed that participants began to shift the labor freed by the program to off-farm activities [67] and increasing numbers of households occupy with off-farm work in city areas because of higher income [23]. However, in the context of China's rapid expansion of urban employment, this labor transfer would doubtless occur even without the SLCP [91]. Another survey [91] is critical about explaining labor transfer by alleviating constraints but supports the idea that the transfer might involve a simple farm-to-nonfarm labor substitution. In summary, non-farm participation and labor supply may not be as sensitive to the program as the policy designers had thought, and the effects of labor transfer changed over the different study periods and differed from one site to another [92].

4.3. What Types of Institutional Challenges are Described?

With the program suffering from an imperfect institutional setting, some features are noted as challenges to its effectiveness in the literature. As the first article appearing in an international journal with regard to the institutional analysis of SLCP, Bennett *et al.* [24] examined the program design and implementation by assessing targeting, conditionality and participation autonomy. The top-down approach and budget distribution were frequently focused upon as problems [24,46]. In addition, Yin *et al.* [31] asked for more concerns on integrated program management, and He Jun [30] called for more attention to local dynamics in policy formulation. However, most of the literature has individually documented the effects of implementation and the institutional setting; much less of it has directly linked different institutional aspects to corresponding outcomes. Therefore, we summarize the following aspects of our literature sorting process under the umbrella of institutional challenges: (a) *the quota system*; (b) *administrative budgeting*; (c) *a multi-goal approach*; (d) *a tree-planting strategy*; (e) *program adaptability*; and (f) *an institutional complementary policy*.

4.3.1. The Quota System

As noted by Bennett [24], the two main innovative elements of the SLCP are volunteerism and the direct engagement of participants. However, the *de facto* hierarchical (top-down) approach in the institutional setting destroyed the original design. According to the Regulations of the SLCP [41], the SLCP is implemented under a target responsibility system. The officials in the relevant departments of local governments at or above the county level will sign responsibility agreements with the higher levels of government that define the responsibilities. At the local level, the chief executives take responsibility for the outcomes, and forest bureaus take responsibility for actual implementation [41]. The performance of these tasks affects these officials' promotions, and there are even punishments for unsatisfactory performance or failures. Under this pressure to meet or exceed quotas, local government officials rushed households to retire much more land than was planned by the central government [31]. In principle, households should have been granted full autonomy in their choice of whether to participate. The government actually ignored the engagement of local people in implementing the program. A village leader survey [93] reported that in interviews with 40 village leaders, only three village leaders stated that participation in the SLCP was entirely voluntary. In most cases, participation was based on a combination of self-selection by households and final selection by the local government [93]. A 2014 study showed that farmers' participation in the SLCP was not voluntary [72].

To facilitate inspection and monitoring by higher-level government officials, some regions gave priority to sites near roads for conversion [24]. This practice resulted in a system that conspired not only to avoid targeting by the project but also to report its success [94]. As a result, some affected households were forced to subscribe to the scheme by village leaders to meet specific conversion targets [70]. Under the quota system, implementation originated from government agreements instead of being based on local conditions, land use practices, or household needs [70]. As result, some poor and environmentally critical areas received fewer quotas than they desired [71].

4.3.2. Administrative Budgeting

Some key administrative challenges of the SLCP include targeting, different agencies' coordination, compensation delivery, local proactive participation and after-program inspection [21,34,35,71]. However, these tasks are burdensome when local governments must pay the administrative costs from their own budgets [24,46]. Local governments have found other ways to benefit from the system by increasing land conversion quotas, exceeding quotas and bargaining for more subsidies [46]. Concurrently, they have sought to minimize administrative costs by including parcels that are contiguous regardless of steep slopes [95]. Consequently, a significant portion of non-sloping land was enrolled, whereas some steeply sloping land remained in cultivation [25].

Another crucial challenge is the program's poor monitoring [32,94]. For example, local budget crises have resulted in minimal monitoring and enforcement of the SLCP [70]. Additionally, given the remoteness of the forestation sites, which discourages monitoring and auditing, and the lack of funding and staffing for the projects, it makes sense for local officials simply to report successes and receive credit for them, particularly when they do not have the means to monitor the reforestation sites [94]. Shortfalls in delivered subsidies also occurred due to poor administrative budgeting [33]. Significant

shortfalls in compensation received occurred in 2003, ranging from 24%–77% in a 2003 survey [24]. In a study by Xu *et al.* [96], approximately 50% of 1,026 households had received incomplete compensation.

4.3.3. Compromise of a Multi-Goal Approach

The dual goals of ecological conservation and alleviation of poverty place local government in a dilemma [24], weakening its ability to ensure program compliance. Withholding subsidies based on low survival rates can significantly dampen enthusiasm for the program and potentially harm households' welfare [24]. Additionally, the SLCP has acquired meaning that far exceeds the program itself. It was initially conceived as part of the "Open the West" campaign [49], which aimed to help China's western provinces catch up economically with the eastern provinces and transfer more rural labor to cities [21,97], which gave the SLCP a means for urbanization.

4.3.4. Tree-Planting Strategy

Opinions differ regarding the SLCP's afforestation strategy, which falls under the responsibility of the SFA [56]. For example, Cao [77] is critical of the SFA's over-enthusiasm for planting trees on sloping land, which has largely ignored local conditions. A study by Wang *et al.* [98] demonstrated that most of the dry land areas in the west have an annual rainfall of less than 400 mm and thus are suitable for growing only grass and drought-tolerant shrubs. Afforestation in vulnerable arid and semi-arid regions, such as those in northern Shaanxi Province, might increase the severity of water shortages, decrease vegetation cover in afforestation plots, and adversely affect biodiversity [51]. Different environments support different vegetation communities, and forests are not suitable for all areas [77]. Moreover, participating households advocate for the planting of trees over grass because of the longer compensation duration [23].

4.3.5. Program Adaptability

Studies [30,53] have indicated that flexible payments and a competitive selection process could be more efficient. Therefore, compensation should differ according to the benefits of certain plot types. The government offers two compensation schemes for the Yellow River Basin and the Yangtze River Basin. No formal pre-program analysis of participants' opportunity costs was conducted [24]. Instead, consideration of opportunity costs was based only on estimates of average regional yields. However, given the tremendous heterogeneity characterizing the two areas, it seems that both compensation schemes would fail to match either environmental benefits or income loss [25]. Regarding the SLCP, Wang *et al.* [54] concluded that the local and regional biophysical and socioeconomic characteristics do not appear to have been sufficiently considered in site selection.

Why does the socioeconomic effect of the program vary in different cases? One reasonable explanation is that the SLCP has different effects on different groups of people. Many researchers [24,25] criticize the program's adaptability because one single policy cannot fit all situations. There are many ways to classify people according to their different responses to the SLCP. Based on the resources they have for cropping, livestock husbandry or off-farm employment, Komarek *et al.* [99] classified different households into four categories. The study indicated that subsistence-oriented households were most

likely to participate in the SLCP, whereas migration- and cropping-oriented households had less incentive to participate. Unlike the mainstream opinion of labor transfer [66], Cao *et al.* [22] found that many households prioritized agricultural development and that fewer wanted support in finding jobs in urban areas rather than assistance with tree and forage planting. These studies demonstrate that different people need different solutions and not a “one-size-fits-all” plan [22].

4.3.6. Institutional Complementary Policy

According to Yin *et al.* [31,40], the success of the SLCP program depends not only on its own stipulations but also on other related policies because the SLCP is devoted to fostering long-term sustainable rural livelihoods through measures such as tenure rights registration. However, the current land tenure system is characterized by insecure land rights due to the separation of land property rights and use rights [100]. Land property plays an important role when subsidies cease, and land rental rights can enhance the sustainability of the program by enabling households to pursue off-farm activities [31]. An analysis [101] also showed that households have a strong aversion for land redistribution and favor the development of more secure land rights (both property rights and rental rights).

Ideally, a market-based approach such as bidding and contracting can help to optimally match payer benefits with participation costs [102]. Programs such as the SLCP can adopt bidding processes to improve the effectiveness of targeting. Additionally, it enables the government to involve intermediaries [40]—including both for-profit and non-profit organizations—and these intermediaries might bridge the gap between the policy initiative at the top and local participants at the bottom [40]. However, it should be recognized that perfect targeting typically cannot be achieved in practice because of increasing transaction costs [31]. Therefore, although differentiated compensation cannot be based on the need of each local plot, it can be made according to plot types [31].

The implementation of the SLCP should be more closely integrated into a portfolio of policies addressing the rural economy. Access to rural credit [24], local livestock management [31], off-farm employment opportunities [66], and the removal of the legal barriers to rural-urban migration policy (“*hukou*” residency permit system) [100] might facilitate the effectiveness of the SLCP socioeconomically. Additionally, complementing the SLCP by other conservation programs would improve all the programs’ effectiveness [21].

5. Discussion

To successfully reach its goals, the SLCP was claimed to be a decentralized and voluntary PES program; however, many institutional barriers have prevented it from being as innovative as it should be. Based on our analysis, we found the importance of institutional aspects, and how they affect the performance of the SLCP in this particular hybrid-governance type. There are multiple institutional driving forces that challenge the effectiveness of the SLCP: (1) the top-down governance regime with quota pressure has shaped the voluntary-based program into a campaign-style mobilization, and this regime has driven the program to quickly achieve tremendous land conversion, but at the cost of comprising local condition; (2) poor budgets have overburdened local governments, leading to poor targeting and loose monitoring, and the program can hardly succeed as its effectiveness wanes; (3) the trade-offs caused by conflicting goals—and particularly the dual goals of land conservation and poverty

alleviation —have put local governments in a dilemma in which punishing poor performance tends to worsen the living conditions of poor households; (4) over-emphasized tree planting has increased the severity of water shortages, decreased vegetation cover, and adversely affected biodiversity; (5) lacking differentiation, the payment scheme did not take local heterogeneity and economic conditions into account in site selection; and (6) land tenure rights, technical support for tree planting and assistance in the labor market did not receive enough attention to ensure the SLCP's long-term impact. We outline the main relationships in Figure 5.

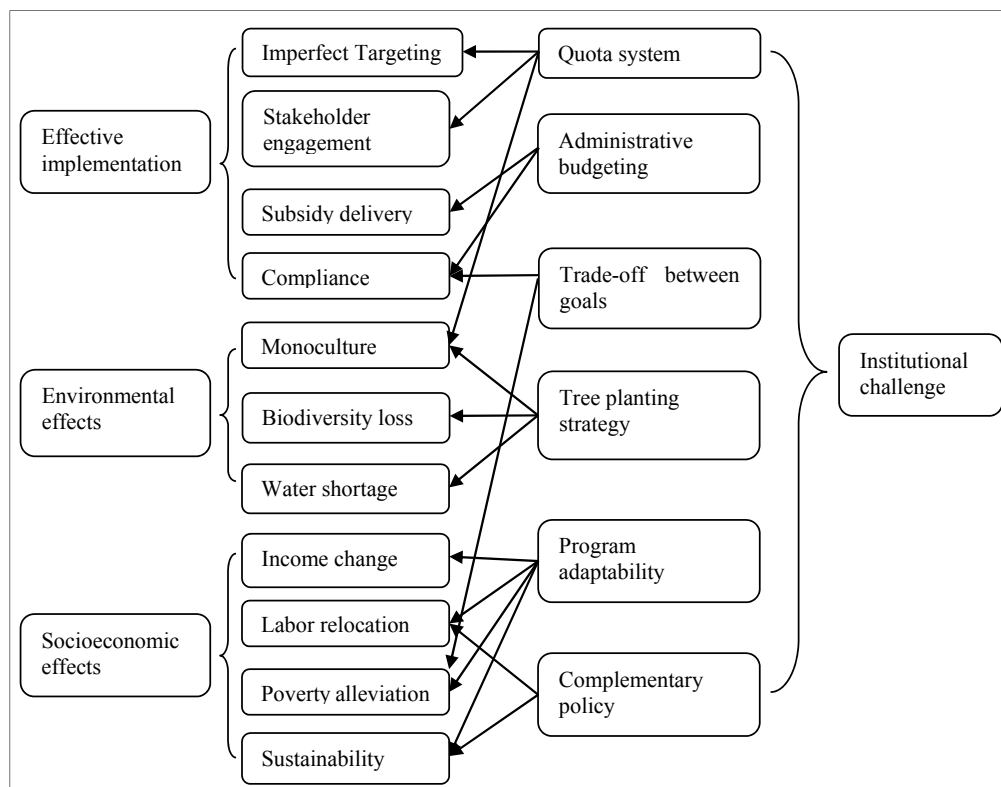


Figure 5. An illustration of the dependence of program effectiveness on implementation.

The arrows indicate the influence on, and the causality of, institutional challenges regarding the deviation between the criteria for program effectiveness and its outcomes. For example, the arrows of the quota system point to imperfect targeting, lack of voluntariness, and monoculture afforestation. Strong incentives to meet the quotas made local governments anxious to complete the task and in the end undermined the principle of voluntariness. There is substantial evidence in the literature that shows that the autonomy of the individual household has not been maintained and that participation is decided by the local government [24].

We acknowledge that the criteria for effectiveness in this figure are not independent of one another. For example, targeting is an element of effective implementation; however, it also causes vegetation cover and livelihood changes. Because we only discuss the deviation between institutional settings and the effectiveness criteria in this paper, we simply place them in different dimensions. Additionally, we

admit the relationships discussed above are by no means an exhaustive description of the complex set of interrelationships between the effectiveness of implementation, environmental effects, socioeconomic effects and institutional challenges. In this figure, we do not intend to precisely reflect these dependencies, but we instead visually summarize the challenges and how they influence the program's implementation and its effects. Further empirical analysis is needed to testify and support the remarks of this review.

6. Conclusions

In this study, we analyzed the key institutional challenges faced by the Chinese PES, the SLCP. Based on a broad literature survey ($n = 164$), we identified the following four institutional aspects in our analysis: (1) program effectiveness (implementation and effects); (2) the difference between program objectives and achievements; (3) institutional challenges; and (4) the dependence of the identified lack of effectiveness on these challenges.

The targeting of the SLCP introduced challenges regarding household participation. In some cases, stakeholder participation appeared less vulnerable, partly as a result of administrative (and pragmatic) implementation issues, the large size of the program and the (relatively short) implementation time allotted. For many households, the program offered new income sources. On the one hand, it was noted that participating households could benefit from the shifting from on-farm to off-farm activities for better economic opportunities. On the other hand, with growing economic development, compensatory payments appeared to be less attractive, and some participating households actually expressed their intention to reconvert their land after the program ends; although evidence showed more and more farmers have off-farm jobs, indicating less need for arable land [23]. The key environmental challenges identified included the selection of appropriate tree species and locations (e.g., tree mortality/survival, water problems, and household issues with maintenance). Nevertheless, these consequences might be linked to certain institutional challenges that made the implementation deviate from the criteria for effectiveness. Studies have shown a large PES program such as the SLCP is a complex and dynamic process in which many relevant actors interact and evolve [32]. From our study, we argue that the program's effectiveness is a result of interacting driving forces, whereas institutional factors such as quota system, program management and relating policies play a key role in shaping the outcome.

This study shows that the concept of PES might be successfully employed in China. In this case, the PES concept provides the basis for considering imperfect institutional settings featuring different environmental and socioeconomic conditions simultaneously. If key relationships are well understood and addressed, the effectiveness of the SLCP can thus be improved. A key finding of this study highlights the dependence of program effectiveness criteria on institutional settings under a hybrid governance regime (a mixture of top-down and voluntary approaches). Using a systematic approach, we conclude that large-scale government-driven PES programs could benefit from adopting the widely accepted principles underlying a typical PES as reflected in policy design, implementation, monitoring and adjustment.

Supplementary Materials

Supplementary materials can be accessed at: <http://www.mdpi.com/2071-1050/7/5/5564/s1>.

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Author Contributions

All of the authors jointly designed and wrote the manuscript. It is part of Cheng Chen's PhD study and he wrote the main part. Bettina Matzdorf wrote the introduction part, Hannes J. König wrote the conclusion part and Lin Zhen contributed to form the structure. All of the authors participated in the revision process and the final manuscript has been approved by all authors.

Conflicts of Interest

The authors declare no conflicts of interest.

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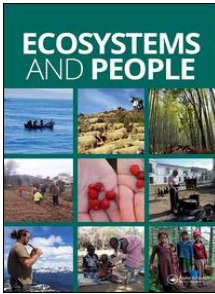
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RESEARCH



How socioeconomic and institutional conditions at the household level shape the environmental effectiveness of governmental payments for ecosystem services program

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ABSTRACT

As the world's largest payments for ecosystem services (PES) program, China's Sloping Land Conversion Program (SLCP) is designed to combat soil erosion and land degradation by converting cropland on steep slopes into forests. Operating through an incentive-based approach, the SLCP involved 32 million rural households as core agents. This paper aims to fill a research gap regarding how socioeconomic and institutional conditions influence rural households to reach the primary environmental goals. Using fuzzy-set qualitative comparative analysis (fsQCA), we conclude that at the household level, the different pathways to environmental success or failure have been shaped by socioeconomic and institutional conditions in a combinatory manner rather than single conditions alone. Specifically, the combination of household involvement and effective monitoring plays a fundamental role in capacity-building between government and households. We found that financial incentives have a trade-off effect, as they could not only create a positive interaction but also trigger failure in situations with different conditions. Finally, the potential and limits of QCA were discussed, and we call for a more serious reflection on the added value of QCA as an alternative or complementary method to conventional approaches in environmental governance research.

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1. Introduction

Payments for ecosystem services (PES) has been a popular approach to address environmental degradation in recent years. The principle of PES is to use an economic incentive to motivate voluntary local actors to protect and restore valuable ecosystem services (Engel et al. 2008). As PES is not a panacea, how to make PES the right tool has attracted considerable attention. Notably, by summarizing 70 PES programs worldwide, Wunder et al. (2018) argue that four theoretical preconditions and three desirable design features should enable PES to achieve success. However, based on a review of PES design features, Engel (2016) claimed that the evidence on the effectiveness of PES is still scarce and rather mixed.

The Chinese Sloping Land Conversion Program (SLCP), initiated in 1999, is considered one of the largest governmental PES programs in the world due to its broad geographic cover, wide participation and tremendous investment (Zhen and Zhang 2011). This program aimed to reduce soil erosion and support rural economic development by reforesting approximately 14.67 million hectares of cropland countrywide (State Forest Administration 2003). With an explicit emphasis on voluntary participation and local autonomy in the policy's

design, the SLCP directly engaged over 32 million households as core agents of program implementation (State Forest Administration 2007). Although embracing innovative PES elements, similarly to other governmental schemes, the SLCP contains components from the traditional command-and-control approach, such as top-down structure, inflexible contract design and campaign-style mobilization (Kolinjivadi and Sunderland 2012). Thus, an open question remains concerning whether the SLCP is an institutional innovation or just 'business as usual' (Bennett 2008).

The success of economic incentive instruments depends on the capacity to target the self-interest of the final agents – the households (Liang et al. 2012; Li et al. 2017). Various socioeconomic and institutional conditions, including household attitude, trust, household involvement, household livelihood, property rights clarification, off-farm labor allocation, and regular monitoring, were considered important factors to create the incentive and shape the behavior (Uchida et al. 2005; Bennett 2008; Cao et al. 2009a). Their influence on rural households' willingness to participate in SLCP was intensively studied (Démurger and Pelletier 2015; Li et al. 2017; Liu et al. 2019). Many studies had linked those factors with program implementation, poverty alleviation, cost-

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 Supplemental data for the article can be accessed [here](#).

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effectiveness and long-term sustainability (Uchida et al. 2009; Gauvin et al. 2010; König, Podhora et al. 2015). Many studies had extensively investigated the various impacts of the SLCP on the participating households, such as their household income (Lin and Yao 2014), livelihood diversification (Liu and Lan 2015), agricultural production activities (Yao and Li 2010; Liu and Henningsen 2016), labor transfer (Yao et al. 2010) and productivity (Liu and Lan 2018). The studies shed light on the factors that affect the program implementation and rural household livelihood. While many longitudinal household databases had provided comprehensive analysis of the livelihood impact of the SLCP, the dependency of the primary environmental goal on socioeconomic and institutional conditions at the household level has rarely been explored. In particular, what determinants influenced the final environmental effectiveness and efficiency at the household level has until now been unclear.

The environmental effectiveness of SLCP is mixed. Environmental effectiveness at the household level refers to the quantity and quality of forest in SLCP-enrolled plots (The State Council 2002). Officially, the most important indicators used to evaluate the outcomes are tree survival rate and canopy coverage¹. While the governmental national evaluation result shows 93% acceptance after inspection (State Forest Administration 2007), many filed studies cast doubt upon the accuracy and reliability of that assessment (Bennett 2008; Trac et al. 2013; He and Sikor 2015). In contrast, several studies found great forest cover improvement in extensive SLCP-enrolled regions by using remote sensing (Zhou et al. 2009; Zhang et al. 2017). Nevertheless, SLCP could not take all the credit, as private commercial afforestation increasingly dominates the expansion of tree cover (Frayer et al. 2014). Additionally, the aggregated regional result may neglect significant differences by individual household and locale (Bennett et al. 2014). Therefore, scientific field observation of the official indicator is important to justify the SLCP-induced environmental outcome at the individual household level. However, due to the difficulty in collecting the filed data in the remote mountainous area, the criticisms of the environmental effectiveness of SLCP primarily relied on secondary data, such as household self-reported information and governmental inspection results (Bennett 2008; Bennett et al. 2014; He and Sikor 2015). Only a handful of filed observations are available, but they are not up to date (Cao 2008; Cao et al. 2009b). To offer direct and detailed evidence, further local case studies and field-based data collection have been called for (Trac et al. 2007).

While there have been several studies devoted to addressing the link between socioeconomic and

institutional conditions with the environmental effects of the SLCP (Bennett 2008; Yin and Zhao 2012; He et al. 2014; Zhang et al. 2017), they have not explicitly clarified the interactions between socioeconomic and institutional conditions and environmental outcomes at the same household level. To fill this research gap, the objective of our paper is to analyze the relation between relevant socioeconomic and institutional conditions and environmental effectiveness at the household level. We target the following research questions:

- What are the necessary and sufficient² socioeconomic and institutional conditions at the household level for environmental effectiveness?³
- What are the necessary and sufficient socioeconomic and institutional conditions at the household level for environmental effectiveness and environmental noneffectiveness⁴?

2. Analytic framework

Our research is structured using a combination of methods. After selecting the case study, we selected and defined the conditions based on the literature and local interviews. Then, we collected data by a second household interview and field observation. After calibration of the data, we employed a fuzzy-set qualitative comparative analysis (fsQCA) to determine the different pathways to success and failure in terms of environmental effectiveness among varied condition arrangements. Figure 1 gives an overview of how we proceeded with our analysis.

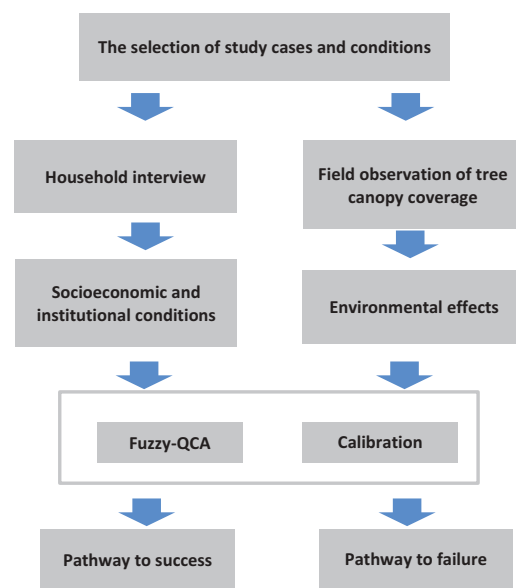


Figure 1. Analytical framework.

3. Selection of case study area and conditions

3.1. Selection of study cases

As a typical target region of the SLCP, Jingyuan County from the Guyuan Region in the Ningxia Hui Autonomous Region (Figure 2) was selected as the study region. Located at the southern tip of the Loess Plateau, Jingyuan County is in a remote, environmentally fragile mountainous frontier region. The county is defined as a national key ecological function zone and is one of the most undeveloped areas in China. Shengli village and Miaowan village were purposely selected because both villages implemented two rounds of the SLCP, with significant tree plantations and extensive involvement of the local households since 2000. To answer our research question, individual households in both villages were selected as our study cases, and their environmental effectiveness for SLCP-enrolled land was defined as the outcome.

Another reason for us to select these two villages is the similarity of their environmental settings. In general, environmental conditions (e.g. soil, precipitation, and temperature) are important determinants of environmental outcomes. Of course, for an individual plot, the micro-environmental conditions are different, especially considering the variation under climate change. However, the land areas in the two villages are categorized into three classes according to biophysical conditions (e.g. slope, soil, access to water and plot size) and traffic conditions (e.g. distance to home). To make the overall quality of land allocated to each household nearly equal, one household normally has 3–6 plots that include all

three classes. Due to the targeting strategy, SLCP-enrolled plots are mostly in the worst class, with the worst biophysical and traffic conditions. By selecting the SLCP-enrolled plots in the two villages, we consider that our sample has been naturally controlled for the environmental aspect. This assumption was also confirmed by the local forest experts. Our first field trip in 2014 observed that one frequently sees two neighboring plots with similar environmental conditions but completely different results due to different management strategies. We therefore believe that for our study cases, environmental conditions may play only a limited role in determining different environmental outcomes across different households.

3.2. Selection of relevant conditions

Consistent with the PES theory and international experience, the environmental success of SLCP depends on a variety of conditions. As only a limited number of conditions can be considered for valid inferences by QCA, we assumed that some key conditions are most relevant for the program's environmental effectiveness. To avoid subjectivity, we selected the most relevant ones through three steps. Step 1 listed the potential conditions through a broad search based on studies. The literature study began with socioeconomic, institutional and environmental aspects that are generally assumed to be important within the SLCP literature. The review, conducted by the first author (Chen et al. 2015) in 2015, includes 164 international scientific articles; additional studies were updated in 2017. As

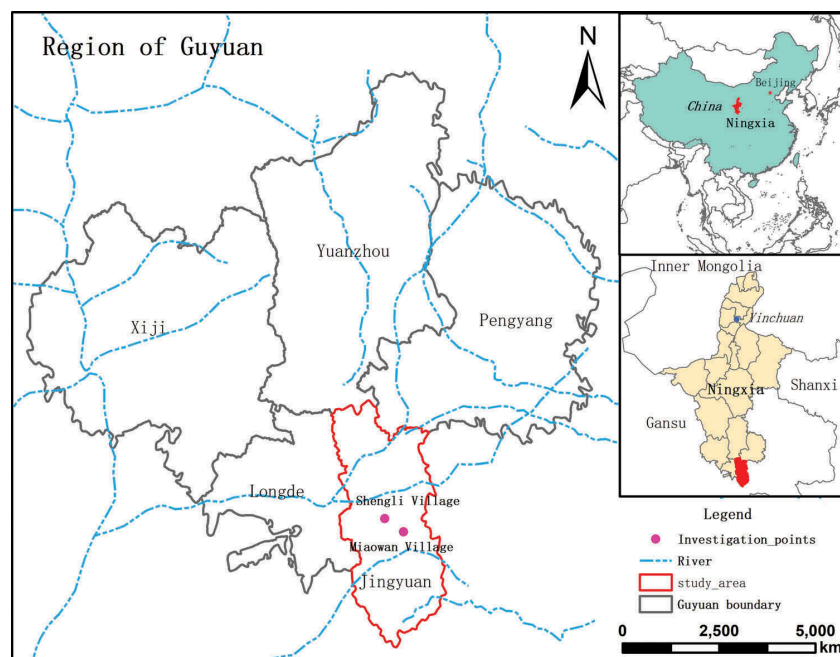


Figure 2. Location map of Jingyuan County in Guyuan region, Ningxia Hui Autonomous Region.

a result, 20 relevant conditions were found. Step 2 shortened the list by merging similar conditions into more-general conditions based on local household interviews. Finally, Step 3 selected the most relevant conditions according to a local expert workshop. Detailed information about this process can be found in A1, the condition selection protocol, in the supplementary material. The final selected socioeconomic and institutional conditions are summarized in Table 1.

3.2.1. Household involvement

The SLCP claimed to be decentralized, and voluntary households were to be free to choose their site to retire and choose tree species to plant (The State Council 2002). However, during implementation, household participation was not entirely voluntary and was observed in a passive manner (Li et al. 2017). When a region was targeted by the governmental general plan, individual households can hardly have a say in the enrollment decision (Démurger and Pelletier 2015). Therefore, we viewed the participation by using the broader term, ‘involvement.’ By our definition, household involvement included being part of the general planning, site selection and tree species selection and of the satisfaction of the decision results.

3.2.2. Financial incentives

For SLCP households, behavioral changes are highly conditional on the governmental payment. Economists viewed the financial incentive based on the opportunity costs (Uchida et al. 2005). However, it is important to consider household resources when analyzing real behavioral changes. Furthermore, the payment amount varied according to the enrolled land size and environmental outcome. Therefore, we define the financial incentive based on the household’s comparison between the cost required by the SLCP (farmland loss, replanting responsibility and obligation to be monitored) and payment received.

3.2.3. Off-farm labor allocation

A household’s position within agriculture and off-farm labor markets has a complicated impact on the program implementation (Uchida et al. 2009). The effect of off-farm labor allocation has been studied intensively but remains unclear. Many scholars have argued that the shifting from on-farm activities to off-farm employment can offer the household better economic opportunities (Yao et al. 2010; He et al. 2014). Therefore, this transition

was considered key to ensuring the converted land is not returned to cropland (Groom et al. 2010). However, other evidence shows that off-farm households do worse at keeping their planted trees alive (Bennett et al. 2011). The percentage of land-related income (farming, gardening and livestock breeding) that accounts for total income is chosen as the measure for off-farm labor allocation.

3.2.4. Property rights

Demsetz (1967) noted that different patterns of property rights could lead to different patterns of behavior, and Tu et al. (2011) found that property rights are generally considered to influence SLCP household behavior regarding resource use and environmental management. Moreover, secure property rights played an important role when payments were terminated by encouraging households to pursue off-farm employment (Grosjean and Kontoleon 2009; Yin and Zhao 2012). However, there are increasing concerns about the uncertainty over the lack of property rights in rural China due to the separation of land property rights and use rights⁵ (Uchida et al. 2005). Since we are interested in the incentive for households to provide environmental effects, the measure of property rights focuses on household perception about trees and land rather than the legal property status.

3.2.5. Effective monitoring

Effective and lasting monitoring, particularly internal monitoring and enforcement, has been understood as a major component of SLCP implementation (Yin et al. 2013). While monitoring was widely accepted as the core of PES design, how to implement monitoring cost-effectively remains unclear (Ezzine-de-Blas et al. 2016). As we consider the monitoring from the perspective of households, household awareness of the checking standard and the appearance of monitoring officials are used as measures.

4. Data and methods

4.1. Data collection – socioeconomic and institutional conditions

Data collection was done during our second field trip in 2015. Thirty households in Shengli village and 29 households in Miaowan village were onsite sampled, totaling approximately 10% of the households in both villages. The survey targeted the household head as the

Table 1. Definition of the five conditions.

Condition	Code	Category	Definition
Household Involvement	‘invo’	Institutional	Household is involved in decision making in program implementation
Off-farm labor allocation	‘off’	Socioeconomic	A majority of income comes from off-farm employment
Financial incentive	‘fina’	Socioeconomic	Household feels the payment is attractive compared to the required input
Property rights	‘prop’	Institutional	Household recognizes property rights for trees and land
Effective monitoring	‘moni’	Institutional	Household is aware of the checking standard and has been effectively monitored

person viewed as knowing the most about his/her household. Apart from basic household characteristics, the interview focused on the five conditions and their measures. In addition, interviews with the village head and local forest officials helped to verify the results from the households.

The subjective impacts from the interviews, such as strategic answers, influence of the interviewer and misinterpretation were seriously considered and carefully addressed. The interviews were conducted face-to-face by a team led by the first author. Since 2014, this team has worked in Jingyuan County, particularly in the two study villages. The team included three PhD students from a research group at the Institute of Geographic Sciences and Natural Resources Research (IGSNRR), Chinese Academy of Sciences. All team members were trained on relevant conditions and corresponding measures. The existing mutual trust and well-prepared knowledge enabled the interviews to be conducted with minimum communication difficulty.

4.2. Data collection – measurement of environmental effects

Tree survival rate was used as the most explicit indicator for evaluation for pragmatic reasons (Bennett 2008). However, it is often criticized by household and local forest officials because survival rate counts the quantity of the trees rather than the quality of the forest. To equally consider the quantitative and qualitative performance, we therefore evaluated environmental effectiveness at the household level by using the Braun-Blanquet method to scale the tree canopy coverage. The Braun-Blanquet cover-abundance scale is a widely used method for ecological studies (Braun-Blanquet 1932) that provides sufficiently accurate baseline data to allow environmental impact assessment in terms of species, estimation of relative abundance, estimation of foliar coverage and density measurement (Wikum and Shanholtzer 1978).

Due to land fragmentation and lacking information, applying remote sensing and GIS to measure the environmental effects for our sampled households is not suitable. The field work was very challenging but appeared to be the only option. We collected field-observed data from 128 SLCP-enrolled plots (Figure C1 and C2 in the supplementary material) owned by our 59 interviewed households. Each household was measured by at least two different located plots because of land fragmentation. We

randomly placed a 100 m² quadrat with the steel tape within the plot during the middle of the growing season (August and September). In order to eliminate accidental in selection, the sample quadrat from the sample plot was checked by our local guide (local farmer specialized in forest management). Species diversity, species number, tree height and coverage were collected according to the Braun-Blanquet table (Braun-Blanquet 1932). The Braun-Blanquet cover-abundance scale was recorded by the authors' estimation in the quadrat. To make our estimation more accurate and objective, we confirmed the scale by counting the number of each tree species in the quadrat. Finally, we adapted the scale with the Chinese forest regulations (Table 2) (General Administration of Quality Supervision 2006). The environmental outcome was categorized 'forest', 'sparse forest', 'developing forest or grass' or 're-farm' (Figure C3 in the supplementary material). According to the Chinese forest regulations, the first two categories are considered forest, and the other two categories are not. Therefore, a coverage ratio of 10% is used as the threshold to distinguish environmental success and failure at the household level (Table 2). We acknowledge that we are not seeking to precisely quantify the environmental effects. Instead, we want to make an estimation of the relative abundance of forest for further outcome comparisons. Given the current availability of data and facility at the household level, the cover-abundance scale in a sample quadrat is an appropriate measure for examining the household-level environmental effectiveness.

As our study case is the individual household, the field observation data from 128 SLCP-enrolled plots need to be aggregated into 59 households. When one household's plots have the same result (45 of 59), they can be easily unified. When one household's plots had different results, a participatory process with the village head was carried out to make a decision based on the overall performance during the previous local inspection. If re-farm is observed in any of the plot, the outcome of the household is labeled as re-farm (9 of 59).

4.3. Data analysis by qualitative comparative analysis

To compare the 59 households, we employed qualitative comparative analysis (QCA) to determine the different pathways to environmental success and failure among varied condition arrangements. QCA, which is based on Boolean logic, allows comparison between cases and at

Table 2. Conversion of Braun-Blanquet cover abundance scale to SLCP scale.

Braun-Blanquet scale	Coverage ratio	SLCP scale	Coverage ratio
3–5	>25	Forest	20%–100%
2	10–25	Sparse forest	10%–20%
1	<10, numerous individuals	Developing forest	5%–10%
+	<10, few individuals	Grass	0–5
R	<10, no individuals	Re-farm	0, crop or nursery planting

the same time offers a detailed understanding of the complexity of each case, particularly in small or medium-sized samples (Ragin 2008). QCA is particularly powerful in analyzing multiple conjunctural and asymmetrical causation (Rihoux and Ragin 2009). Multiple conjunctural causation means that 1) not one factor but a combination of factors will lead to the outcome; 2) different combinations of factors can produce the same outcome; and 3) one condition can have different impacts on the outcome, depending on its combination with other factors and the context. The justification for considering QCA as an appropriate method for our study can be found in A2 in the supplementary material.

Hypotheses within QCA are implication hypotheses of the notions of necessity and sufficiency (Ragin 2008). A condition is necessary if, whenever the outcome is present, the condition is also present. A condition can be interpreted as sufficient, if always whenever the condition is present, the outcome is also present. The QCA analyses presented in this paper were conducted with fsQCA 2.0 software (Ragin 2008). The software used the truth table to sort the condition data into the different logically possible combinations. When applying the logical minimization procedure to the truth table rows, three solution terms are produced: the complex solution, the parsimonious solution and the intermediate solution. With no simplifying assumption, a complex solution avoids using any counterfactual cases (remainder). Parsimonious solutions, on the other hand, permit the use of any remainder that will yield the simplest recipes. An intermediate solution is something in between; it uses only the remainders that survive counterfactual analysis based on theoretical and substantive knowledge. The researcher is free to choose the solution for substantive interpretation depending on the balance between complexity and parsimony (Ragin 2008). Finally, to explain inconsistencies, contradiction analysis is used to explore why some of the cases covered by the sufficient condition exhibit the outcome and others do not.

The comparison of QCA and classical regression analysis (e.g. binary logistics) is by far a mixed result (each has merits and drawbacks). As this study does not intend to compare the methods, readers can find a detailed discussion in the works of Seawright (2005), Grofman and

Schneider (2009) and Vis (2012). We acknowledged that this method is only briefly introduced in this section of this paper. Our recent publication explains how QCA could be applied in institutional analysis for PES and illustrates five basic steps for such application (Meyer et al. 2018). In Ragin (2008, 2014) and Schneider and Wagemann (2010, 2012) provide handbooks, user guides, explanations and standards of good practice regarding this method. Nevertheless, to facilitate the understanding of the results and discussion, we summarized the basic terminology in Table B2 in the supplementary material.

4.4. fsQCA and calibration

Crisp-set qualitative comparative analysis (csQCA), specifically, an early developed version with dichotomy, was first introduced by Charles Ragin in 1987 (Ragin 2008). As csQCA was criticized by using binary-value data, fuzzy-set QCA (fsQCA) allows the researcher to establish differences in degree through a fuzzy membership score (Schneider and Rohlfing 2013). The membership score is usually generated by calibration, and this crucial process should be transparent, open and replicable (Ragin 2006). The fuzzy membership score of our four conditions was a four-value scheme with '0', '0.33', '0.67', and '1.0' to indicate 'fully out', 'more out than in', 'more in than out', and 'fully in', respectively. Since the household involvement is more complicated, the fuzzy membership scores of household involvement employed a six-value scheme, with values of '0', '0.2', '0.4', '0.6', '0.8' and '1.0'. Similarly, the fuzzy membership outcome scores were categorized with a four-value scheme to indicate 'forest', 'sparse forest', 'developing forest or grass' and 're-farm'.

Theoretical knowledge and empirical insight were used to generate the fuzzy membership scores of each condition by using a measure. The selection of the measure followed the structural calibration procedure suggested by Basurto and Speer (2012). Each condition was explained by a measure, and each measure corresponds to a survey question (Table 3). The full dataset can be found in table B1, and details of the calibration process are summarized in table B3 in the supplementary material.

Table 3. Measure of condition.

Condition	Measure	Survey question
Household Involvement	Involvement in general planning	Were you involved in the program general plan in the village?
	Involvement in tree selection	Were you involved in the tree species selection for your own enrolled land?
	Involvement in site selection	Were you involved in the site selection for your own enrolled land?
	Satisfaction	Were you satisfied with the tree and spot selected for your SLCP enrolled land?
Property rights	Tree ownership	Do you think you own the tree under the payment?
	Tree disposition	Do you think you own the tree after the payment?
	Land ownership	Do you think you own the enrolled land?
Off-farm labor allocation	Income structure	How much is your land-related income?
		How much is your total income?
Effective monitoring	Checking standard	Do you understand the checking standard?
	Monitoring	Have you been regularly monitored by a local official?
	Inspection	Did the provincial or national official inspect your SLCP enrolled land?
Financial incentive	Recognition of attractiveness	Do you feel the payment is attractive compared to the input that is required?

5. Results

5.1. Monitoring of environmental effects

In Jingyuan, ecological planting (species that provide ecological services, compared to fruits and nuts) has been fully implemented due to longer payment, as the local government promoted. Local forest experts told us that ecological trees grow better on SLCP-enrolled land in Jingyuan, which has poor soil fertility. Inappropriate choices of tree species were made in the first few years, given the study region's low water availability and harsh winter (König et al. 2014), and replanting was conducted every year to fill the gaps left by dead trees. Thus, local governments, on behalf of the program, asked the households or hired local laborers to participate in replanting. Years later, due to many rounds of replanting, a mixed plantation of many indigenous species was established by the households. However, many households complained that the payment was greatly reduced due to the replanting.

A majority of trees on the ground are less than 3 meters tall, with low coverage (Table 4) and low density (Table 5). Most of our observation plots are at the early stage of forest development. The average self-reported tree survival rate is 65.4%, while the field-checked tree survival rate⁵ is 40.46% (Table 5). Both figures are much lower than the official 85% standard, implying that there may be a serious problem with tree management. Sixteen of 59 households had delivery of a qualified 'ecological forest', and they will be entitled to annual compensation by categorizing their forest into a national public forest. Forty-three households had not achieved the expecting environmental outcome, and 9 households had reconverted their SLCP-enrolled land back to agricultural use.

5.2. Pathway to success

We assumed that the presence of household involvement, property rights, off-farm labor allocation, effective monitoring and sufficient financial incentive is relevant for environmental success.

5.2.1. Necessary conditions

For this study, we used a consistency score of 0.90 as a threshold for accepting a condition as being necessary, as suggested by Schneider and Wagemann (2010). The analysis showed that all consistency scores are below the threshold with an exception that the condition of

Table 5. Descriptive statistics of tree number and survival rate of 128 SLCP-enrolled 100 m² quadrat.

	Number of trees	Survival rate
Mean	13.75	40.46%
Standard Deviation	10.27	0.26
Minimum	0	0
Maximum	78	1
Count	128	128

effective monitoring (0.897683) is very close to 0.9, indicating that effective monitoring is likely the necessary condition for success.

5.2.2. Sufficient conditions

By performing a sufficiency analysis, we sought to determine which individual conditions or combination of conditions would be sufficient for achieving the outcome. All 59 cases were used to build the crisp-set truth table, with 24 rows (figure C4 in the supplementary material). The outcome value of each row was determined. We found a clear gap between the outcome consistencies of 0.82 and 0.79 (marked as red in figure C4); therefore, we used the natural break of 0.8 as the threshold. QCA is a case-oriented method and is very sensitive to case. To avoid over-interpretation, we set the frequency at 2. Thus, five rows were considered successful and 19 rows unsuccessful (figure C4). We identified two solution terms for sufficient conditions for success (Table 6). The verification of the QCA solutions for inconsistencies and noncoverage can be found in A3 in the supplementary material.

Accordingly, the results of our sufficiency analysis are graphically displayed through an XY plot (Figure 3) that can be used to visualize how consistent a given combination of conditions is with the statement of being a sufficient condition. The axes show the fuzzy-set membership scores of the cases in the set of condition X and the outcome Y. For sufficiency, each case's fuzzy-set membership score in X must be equal to or less than its fuzzy-set membership in Y. In other words, almost all cases falling above the main diagonal would indicate a sufficient relation. In this figure, most cases are above or on the bisecting line.

5.3 Pathway to failure

Similar to our analysis of environmental success, we assumed that the absence of household involvement, property rights, effective monitoring or financial incentive is relevant for environmental failure. However, the effect of off-farm labor allocation is not clear in the literature. Therefore, we retained both on-farm labor allocation and off-farm labor allocation in the assumption. The condition code was marked with a tilde (~), indicating the status of absent.

Table 4. Coverage of 128 SLCP-enrolled 100 m² quadrat.

SLCP scale	Coverage ratio	Number of plots	Percentage
Forest	20%-100%	23	18%
Sparse-forest	10%-20%	16	12.5%
Developing-forest	5%-10%	27	21.1%
Grassland	0-5	49	38.3%
Re-farm	0	13	10.2%

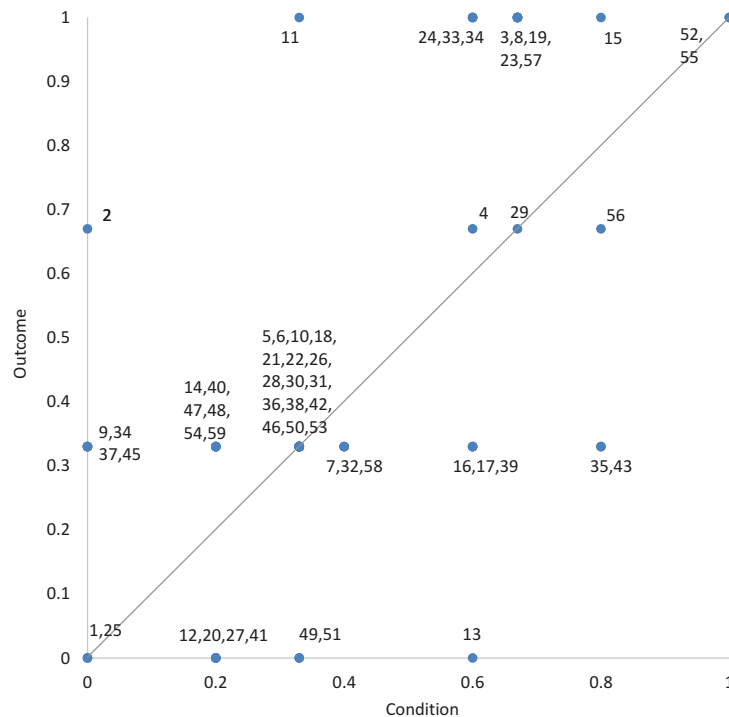
Table 6. Sufficient conditions for success: complex solution.

Term	Solution	Raw coverage	Unique coverage	Consistency	Covered household number
1	invo*moni*fina	0.708494	0.411583	0.851113	3, 4, 8, 13, 15, 19, 23, 24,29, 33, 35, 39, 43, 44, 52, 55, 56, 57
2	invo*moni*prop*off	0.335135	0.038224	0.843538	4, 8, 16, 17, 39, 52

Model: out = f(part, prop, off, moni, fina)

Solution coverage: 0.746718, Solution consistency: 0.823329

Frequency cutoff: 2.000000, Consistency cutoff: 0.824345

**Figure 3.** XY plot of solution for sufficient condition invo*moni*fina + invo*moni*prop*off.

5.3.1. Necessary conditions

The analysis of necessary conditions of environmental failure indicated that none of the five conditions was necessary for the outcome.

5.3.2. Sufficient conditions

We use the intermediate solution as a result because it balances parsimony and complexity via the injection of additional theoretical knowledge into the analysis. Again, we set 0.8 as the threshold according to the natural break (marked as red in figure C5 in the supplementary material) and set the frequency at 2. Thus, we identified three solution terms for sufficient conditions for failure (Table 7). The verification of the QCA solutions for inconsistencies and noncoverage can be found in A4 in the supplementary material.

6. Discussion

6.1 Conditions for environmental effectiveness

According to the necessary condition analysis, consistency of effective monitoring is very close to the

threshold, indicating that monitoring is practically the only necessary condition for an environmental success at the household level. The results of our sufficient condition analysis indicate that the combination of certain conditions rather than a single condition alone is crucial for environmental effectiveness. The results reveal one main path and one complementary path, which include both socioeconomic and institutional conditions. The two different paths can independently lead to environmental effectiveness (multiple conjunctural causation).

Each path contains the combination of household involvement and effective monitoring, illuminating them as a fundamental combination. This combination can create platforms for negotiation and capacity-building between stakeholders. Both social systems and ecosystems are nonstatic, and the governmental PES needs to cope with abrupt change. Specifically, a reforestation program such as the SLCP requires closely cooperating stakeholders who deal with general planning, location and tree species selection, and problem solving. The initiation of SLCP includes choosing saplings, planting at the right time, digging a good-sized

Table 7. Sufficient condition intermediate solution. Assumptions: ~fina (absent) ~moni (absent) ~prop (absent) ~part (absent).

Term	Solution	Raw coverage	Unique coverage	Consistency	Covered household number
1	~off*~invo	0.511783	0.172508	0.870504	6,12,20,21,26,27,28,32,37,38,41,45,47,48,49,51,53,54,58
2	~prop*~invo	0.434441	0.048640	0.892613	5,6,7,14,26,27,28,37,40,41,49,51,59
3	fina*~moni*~prop	0.322054	0.073112	0.889816	5,6,9,28,36,37,41,46,50,59

Model: out = f(~part, ~ prop, ~ off, ~ moni, ~ fina)

Solution coverage: 0.680061, Solution consistency: 0.873836

Frequency cutoff: 2.000000, Consistency cutoff: 0.816568

hole and keeping the soil moist. Failure of any of these factors can lead to extensive tree death, poor growth, or a decline after planting. The fundamental combination urges the households to manage their saplings at an early stage, establishing a strong resistance to later environmental challenges such as open livestock grazing, drought, cold and rodent damage. For example, 2007 saw the coldest winter in Jingyuan in the last decade, and massive damage to trees occurred. Therefore, long-lasting household involvement and effective monitoring are needed for both initiation and follow-up replanting. Our results confirm the hypothesis that PES schemes that are serious about involvement and monitoring will also tend to perform better with respect to their environmental outcomes (Ezzine-de-Blas et al. 2016). Nevertheless, environmental success can only be expected from the occurrence of a fundamental combination with either 1) a financial incentive or 2) both property rights and off-farm labor allocation.

6.1.1. Path 1: the combination of household involvement, effective monitoring and financial incentives

Due to the high coverage (14 of 16 successful households), path 1 is the main path to environmental success. It shows that the fundamental combination has to be consistent with financial incentives. As primary incentive, payment is important for the properly initiated households to maintain their efforts. In contrast, payment to those who failed to pass the checking standard can be largely deducted and use to contribute to replanting costs. This path can focus the households' incentive away from one-time behavior and towards long-lasting efforts by creating a positive feedback loop.

Notably, clear property rights and off-farm labor allocation are missing in the combination, which has challenged many studies (Uchida et al. 2009; Tu et al. 2011) by showing that clear property rights and off-farm labor allocation are irrelevant for the main path to environmental success. In Jingyuan County, local employment opportunities are limited and unstable. Most off-farm employment is physical work in the construction and service sector. This kind of employment often has no contract and is excluded from the social security system. The households covered by this path showed varied recognition of property rights. Only 3 of 14 successful households could explicitly recognize

a property right. Therefore, we argue that the instability of off-farm work in poor areas and the vagueness of property rights in rural villages may undermine the two important conditions for environmental effectiveness.

6.1.2. Path 2: the combination of household involvement, effective monitoring, clear property rights and off-farm labor allocation

The second path shows that environmental effectiveness can also be expected in the presence of a fundamental combination together with clear property rights and off-farm labor allocation. Complementary to the main path, this path describes how to reach environmental success for a special group of off-farm households. Although a majority of the income came from off-farm employment and their dependency on the land was increasingly weak, the three successful households covered by path 2 (household numbers 4, 8, and 52) hold strong concerns about the risk of unemployment. Therefore, they wanted to strengthen their ownership of the trees and the land as a safeguard.

The financial incentive is not a component of the path for off-farm households, although three successful households had two '0.67' and one '1' in the value scheme of the financial incentive. Due to the inconsistent cases (household numbers 16, 17, and 39), the logic minimization procedure treated financial incentive as an irrelevant condition. While the payment was important at the early initiation stage, three successful households told us that this importance was increasingly weak as time passed. As off-farm employment has recently dominated total income, the payment of SLCP was only viewed as 'icing on the cake'. Therefore, we argue that it is not necessary to add a financial incentive to the combination.

6.2 Conditions for the failure of environmental effectiveness

Similar to the conditions for environmental effectiveness, failure can occur from a combination of certain conditions rather than single conditions alone. Additionally, asymmetrical causation was also observed. Conversely, the presence of certain conditions linking with environmental effectiveness does not imply that their absence links with failure.

In the absence of certain conditions, the SLCP may become either business as usual or a form of welfare entitlement. In particular, household noninvolvement

occurred in paths 1 and 2, showing that when program implementation was informed rather than discussed with households, their environmental effectiveness may be harmed at the household level. As Bennett (2008) found, incomplete involvement may place some households in an unfair situation in terms of resource distribution. Indeed, some households complained that the saplings they received were bad quality compared with those households who kept a close relationship with local forest officials. Corresponding to section 6.1, household involvement plays a large role in determining both success and failure of environmental effectiveness.

A negative effect of off-farm labor allocation was not found in any of the three paths, which challenges the argument that off-farm labor allocation may endanger tree management due to time conflict or geographic mismatch between city-based off-farm employment and village-based forests (Bennett et al. 2011; Li et al. 2017). In Jingyuan County, most off-farm laborers commute between the construction sites and the villages by motorcycle. The short distance does not place the on-farm and off-farm work in contradiction. Thus, off-farm labor allocation may not play a role in the failure of environmental effectiveness.

6.2.1. Path 1: the combination of household noninvolvement and on-farm labor allocation

Households covered by this path have continued their dependence on farming and lost the chance to diversify their income. Many scholars assumed that it is more likely that the on-farm labor allocating households and relatively poor households will reconvert some of the SLCP forest back to farming when the program ends (Grosjean and Kontoleon 2009). The households covered by this path confirmed this assumption; five households had already reconverted some of the SLCP forest back to sapling nursery or forage (alfalfa) planting. Our results reflect the assumption of Barbier (2010) of a 'poverty-environment trap' in developing countries, where the relationship between poverty and natural resource degradation is affected by the people's access to outside employment. Households covered by this path may be resistant to both sapling initiation and repeated replanting because they distrust the implementation process and they simply need the land for agricultural use. Therefore, we argue that an environmental failure can be expected in the presence of household noninvolvement and on-farm labor allocation, where distrust, initiation failure, poor replanting and farm dependency are all mutually reinforcing.

6.2.2. Path 2: the combination of poor property rights and household noninvolvement

The combination of household noninvolvement and poor property rights can also lead to failure. While half of the covered households of the second path

overlapped with the first path due to the presence of household noninvolvement, it is interesting to notice the appearance of poor property rights. To date, forest tenure reform allocated forestland to households but caused more ambiguity about forest ownership (He et al. 2014). Households covered by this path have doubts about their property rights and hardly consider the enrolled land their property, discouraging them from managing the forest appropriately in the long term. Similarly, in Vietnam (Kolinjivadi and Sunderland 2012), Cambodia (Clements et al. 2010), and Indonesia (Fauzi and Anna 2013), the implementation of governmental PES has been challenged by the lack of well-defined property rights, raising a question about the suitability of PES as a suitable tool in some developing countries.

6.2.3. Path 3: the combination of financial incentive, weak monitoring and poor property rights

This path may be viewed by households as a form of welfare entitlement or a profitable cheating strategy. Particularly when the payment is attractive, monitoring is not in place and property rights are not clear, households consider the SLCP compensation instead of conditional payment. Our results are supported by the study of Ezzine-de-Blas et al. (2016), who found that governmental PES schemes that are perceived to be ill-monitored will often eventually lead to widespread noncompliance.

The trade-off effect of financial incentives is worth mentioning, since it is a component of a successful path and a failed path. It may be considered an inconsistency by the regression analysis, but it is absolutely normal in the QCA analysis. The multiple conjunctural causation of QCA allows one condition to have different impacts on the outcome, depending on its combination with other conditions. Therefore, when combining with different conditions, financial incentives can trigger not only success but also failure.

6.3 Policy implications

Our study could be a reference to improve the governmental PES programs. Governmental PES has great potential to create significant economies of scale and cost efficiencies when compared to other types of PES (Engel et al. 2008). However, the tremendous investment from the state does not necessarily guarantee the expected environmental outcome. Attention should be given to understanding the combined effect of conditions on PES program goals. Several studies have presented certain design features and synthesized some common conditions for PES (Sattler and Matzdorf 2013). However, most existing studies consider the various conditions individually and independently.

Notably, Meyer et al. (2015) first showed that combinations of certain design rules influenced the success of a governmental payment scheme in Germany. Similarly, our SLCP study shows that the combination effect of certain conditions rather than single conditions alone should be considered. In particular, for a successful reforestation program, household involvement, effective monitoring and financial incentives should be present in a combination. While reforestation requires continuous management with a trustable reward system, this combination can foster a positive feedback loop by building long-lasting cooperation between households and government. The present of both socioeconomic and institutional conditions shows that interaction of socioeconomic and institutional conditions may have a direct impact on the environmental outcome. However, the interactions discussed in this paper are by no means an exhaustive description of the complex set of interrelationships between socioeconomic, institutional and environmental dimensions. We therefore call for more attention to combination effects when designing a PES scheme.

Our study provided new empirical evidence that is relevant for SLCP policymakers. First, our field observation was in agreement with the claim that environmental effectiveness decreased to thresholds below those stipulated for payment. Second, the effect of labor allocation is clear in our results. On the one hand, off-farm labor allocation is the key component of the complementary path to success. On the other hand, households who continued their dependence on farming may be trapped in poverty. Third, the income structure change does not make those off-farm households relax their property right claims to their SLCP land and trees. Therefore, the strength of property rights is needed in future policies, especially for those off-farm households who successfully developed the trees. In late 2016, the central government decided to terminate the payment (State Forest Administration 2016). From 2017 onward, the successfully established 'ecological forest' could be categorized as a national public forest, which is entitled to annual compensation. The successfully established 'economic forest' can be developed with the under-forest economy (agroforestry) and even allowed to be cut down if permitted by a local authority (State Forest Administration 2016). However, the termination did not offer a solution to those households who failed to meet the evaluation standard. Therefore, timely policies should be made to address these 'excluded' households by guiding them from previously failed paths to successful paths. In particular, the combination effect of household involvement and governmental monitoring can help households break down institutional constraints.

6.4 Methodological discussion

The Braun-Blanquet method was used to evaluate the canopy coverage of SLCP-enrolled plots as an indicator of environmental outcomes. Similar to other ecological study methods for vegetation analysis, the result depends on the time of the field visit. For instance, deciduous trees may have different coverage in different seasons. Moreover, the difference in tree species can influence the result. For example, broadleaf trees (e.g. black locust and Elm) in general have larger coverage than do coniferous trees (e.g. dahurian larch and pine). In our study region, both broadleaf trees and coniferous trees were mixed planted, and trees were qualitatively different due to different planting times. Therefore, we consider that the Braun-Blanquet method is a better tool to compare survival rates.

Our results confirm that QCA has the advantage in the identification of necessary and sufficient conditions and multiple conjunctural causation. However, disadvantages of QCA, including reduced case numbers, limited causal conditions (Rihoux and Lobe 2009), subjective condition selection and imperfect calibration (Basurto and Speer 2012), have also been observed. Similar to other case-oriented studies, fsQCA faces the same challenge that only a limited number of cases and conditions can be considered if one wants to draw valid inferences. High numbers of conditions might be dysfunctional for QCA, just as in garbage can statistical models, where too many independent variables 'destroy' the results (Schneider and Wagemann 2010). As is always true in QCA, the number of cases is equal to 2^K , where K is the number of conditions included in the study. Our number of cases is 59, and our number of conditions is 5, which are suitable for the QCA application. Moreover, the selection of conditions has a strong impact on the research result; therefore, strong arguments are required to avoid subjectivity (Sehring et al. 2013). In our SLCP study, the conditions were selected and defined based on theoretical knowledge and an extensive participatory process. However, several important conditions (e.g. trust and norm) were excluded from our final five conditions. Authors must constantly justify their choices and make them transparent (Table B1). As a key part of fsQCA, calibration is essential to the reliability and replicability of the result. Therefore, it needs to be done carefully and documented clearly and in detail. We kept the selection and calibration of conditions transparent (Table B3) and open to criticism. We thus believe that this openness has helped to balance the subjectivity inevitably involved in any qualitative research.

As a 'middle road' between quantitative and qualitative strategies (Rihoux 2003), QCA may go beyond them by making systematic comparisons while still taking into account the single case (Meyer et al. 2018). Despite being a well-established tool for policy research, the application of QCA in the field of

environmental governance is rare. As the potentials and limits of QCA were reflected by our SLCP study case, the added value of QCA as an alternative or complementary method to conventional research approaches might be discovered. The advantages of QCA may be especially relevant in terms of research on PES, which requires a better integration of relations between institutional, socioeconomic and environmental issues (Meyer et al. 2018).

7. Conclusions

In this study, we examined two major aspects. First, the paths of socioeconomic and institutional conditions to environmental effectiveness of the SLCP at the household level were revealed. Specifically, the linkage between two interrelated datasets of socioeconomic and institutional conditions and field-observed environmental outcomes were directly explored. Second, our study is the pioneering work to use fsQCA in environmental governance research for PES, and the added value of QCA might be discovered. By correctly reflecting its potentials and limits through empirical application, we call for a more serious reflection on the added value of QCA as an alternative or complementary method to conventional research approaches.

Our field observation data from 128 SLCP-enrolled plots are arguably one of the few datasets thus far available for SLCP field-observed evaluation. We show that 16 of 59 households had successfully implemented the SLCP and that 9 households had reconverted their SLCP-enrolled land back to agricultural use. The success and failure in terms of environmental effectiveness can be expected based on the combination of certain conditions rather than single conditions alone. Our results revealed one main path and one complementary path, either of which can independently lead to environmental success. As replanting was annually conducted to replace the dead trees in some areas, long-lasting incentives in situations with effective monitoring appear to be critical for the environmental outcome. The pathways to failure in environmental effectiveness were more complicated. The first and second paths were considered business as usual, and the third path was viewed as a form of welfare entitlement or a profitable cheating strategy. We found that financial incentives have a trade-off effect, as they can not only create a positive interaction but also trigger failure in situations with different conditions.

Notes

1. At the household level, environmental effects were measured by the tree survival rate (counting the trunks 3–5 years after the saplings are planted), tree species and canopy coverage. At the regional and national levels, environmental effects were measured by the increase in forest area and forest cover.

2. Necessary and sufficient conditions refer to QCA terminology; please see section 3.3 and Table B2.
3. The outcome and the negation of the outcome should always be analyzed in two separate QCA analyses.
4. In the early 1980s, through forest tenure reform, most collective forests in rural China came under the management of individual households.
5. We checked the survival rate according to the official standard, which uses number of survived trees divided by number of planted seeds or seeding ($666.67 \text{ m}^2 = 220 \text{ seeds/seeding}$) after a 3 to 5-year period from time of planting. The first planting was in 2000, but the re-planting was annually repeated until 2013. The survival rate was measured in 2015, which is three years after the latest re-planting and close to the end of the program.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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Working Paper

The Network of Actors in a Governmental PES Program: Local Governance Models for China's Sloping Land Conversion Program

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Abstract: This study examines the network of actor for the implementation of a governmental PES program in China. We use Net-Map, a participatory network tool for social network analysis (SNA), combined with household survey to analyze how different stakeholders understand the program and how they influence each other. The results of our case studies in three townships showed that the local dynamics derived and shaped the program implementation. We found that the local agencies could potentially bringing together government and local farmers for up-front negotiations. Local institutional actors, including local government agencies, village councils, forest field stations and farmers may be forced to coordinate and ideally deliberate the terms and conditions of implementation and management options. Therefore, particular attention should be paid to the local governance models and interaction of local actors.

Key words: Governance, governmental PES, SLCP, social network analysis, Net-Map, China

Introduction

The policymakers in China are increasingly interested in the market-based and incentive-based approach to address the country's conservation challenges and resource constraints. While Payment for Ecosystem Services (PES) is increasingly popular as a way to manage

ecosystems using economic incentives, its applications in China have been known under the domestic term of “eco-compensation” (Bennett 2009). Some eco-compensation schemes in China were recognized as PES-like or governmental PES schemes, as direct payment is often made by governments and the market mechanism is not yet fully in place (Wunder 2015). There are good arguments that this type of governmental PES fits well with the existing institutional and socioeconomic setting, especially when environmental conditions are in conflict with economic growth, rapid urbanization, expanding populations and social fairness (Liu and Diamond 2005). Other argued that eco-compensation in China lagged behind mature foreign PES projects in social negotiations, local acceptance, effectiveness and sustainability (Shang, Gong et al. 2018).

As the flagship program of eco-compensation, the Sloping Land Conversion Program (SLCP), does not really fit the mainstream definition of the market-based approach, yet has been put under the label of one of the largest PES. This program aimed to reduce soil erosion by reforestation approximately 14.67 million hectares of cropland countrywide (State Forest Administration 2003). With stated principals of volunteerism and special emphasis on local engagement, central government provides payment to voluntary participants for land conversion, which is presumes to improve the provision of ecosystem services in the future. It includes both voluntary and hierarchical elements (top-down). However, the questionable property right and government’s political-campaigns-style strategy were often criticized by international scientific community (Bennett, Mehta et al. 2011, Yin and Zhao 2012).

The central-designed policy had few modifications to adapt with the quite diversified ecological and economic conditions across the country (Chen, König et al. 2015). It left a significant variation for local practitioners to understand the policy and made room for different interpretation. Therefore, the implementation of SLCP has largely relied on local agencies and farmers (Xu, Tao et al. 2010), although the central government has the formal authority over the program design. However, nearly two decades of implementation, the National Forestry and Grassland Administration (formally recognized as State Forestry Administration) from central government had not developed effective incentives in mobilizing local cooperation in the SLCP. The eco-compensation programs over-depend on bureaucratic incentives, such as career promotion and administrative punishment, but seemed to ignore local agencies’ demand of financial compensation for their implementation efforts (Yu 2016).

Local agencies were considered important to ensure the social negotiations and voluntary acceptance. Many studies had observed the violation by local agencies (Trac, Harrell et al. 2007, Bennett 2008), contradicting to central government's stated principals of volunteerism. However, understanding the perception of local agencies and farmers toward the central-designed governmental PES and their interaction with other actors are until now not clear yet. In order to fill this knowledge gap, this study aims to examine the recognition of different actor toward SLCP implementation. In particular, we focus on

- 1) How is the actors' network perceived?
- 2) How is the PES implemented at the local level?

Case study

As a typical target region of the SLCP, Jingyuan County from the Guyuan Region in the Ningxia Hui Autonomous Region was selected as study region. Located at the southern tip of the Loess Plateau, Jingyuan County is in a remote, environmentally fragile mountainous frontier region. It is defined as the national key ecological function zone and is one of the most undeveloped areas in China. Xingsheng Township, Huanghua Township and Xiangshui Township were purposely selected because they implemented two rounds of the SLCP with significant tree plantations and the extensive involvement of the local farmers since 2000.

Method

Social Network Analysis (SNA) is a suitable methodology to uncover involved actors, their motivations and power relations, and institutional settings. Thus, SNA can be used to bring transparency into PES governance and to foster social learning and coproduction of network knowledge. These aspects have been proven to support the closure of similar gaps in other areas of environmental governance (Hauck, Stein et al. 2015). Net-Map is an interview-based mapping tool that helps stakeholders understand, visualize, discuss, monitor, evaluate and improve situations in which many different actors influence outcomes. Net-Map is a hands-on, low-tech, participatory tool, which can be used as a facilitation tool, or in the context of in-depth interviews. By creating Influence Network Maps sheets, individuals and groups can clarify their own views of a situation, foster discussion, and develop a strategic approach to networking activities.

In our case, we firstly asked about the actors in the implementation of SLCP. In the second step, we asked the pre-defined link(s) between the actors, including task assignment, knowledge flow, reporting and monitoring. In the third and fourth step, the influence and importance of the actors was measured. In the fifth step, the motivations of the actors were elicited. These five steps serve as a guideline for visualising a network map together with the interview partners (Table 1). This visualisation process is accompanied by interviewing, which the interviewees provide to explain the drawings.

The information contained on the Net-Map sheets was later digitised in order to be analysed in the form of network graphs and their related SNA measures. The analysis of the Net-Map data was performed through the use of program UCINET (<https://sites.google.com/site/ucinetsoftware/home>).

Step	Goal	Question
1	Actor identification	Do you know any actor involved in the implementation of SLCP
2	Links	Task assignments (Who tells whom to do the SLCP)
		Advisory (Who discusses with whom about the targeting place and tree species)
		Report about outcome (Who reports to whom the result)
		Monitoring (Who inspect whom about the result)
3	Influence tower	How influential is this actor? Give a score between 0 and 5
4	Importance tower	How important is this actor? Give a score between 0 and 5
5	Goal	What is the goal for the actor in the program? Monetary benefit/environmental conservation/rural development/obligation require

Table 1: Net-Map interview process

In additional, survey of farmer perception was used as supplement to help the interpretation of the Net-Map data.

Date collection

Data collection was made by our field trips in October 2014. Both qualitative (through Net-Map interview) and quantitative (through household surveys) data were collected. 31 Net-Map interviews were conducted, including policy makers, local executive officials and local farmers. Six policy makers are from higher administrative level, ranging from Ningxia provincial government, Guyuan prefecture government and to Jingyuan county government. Above the county level, three townships were further selected for local executive actors. Each township has one forest station and the chief of the station was interviewed. Each township has several villages and four villages from the three townships were selected. The village chiefs (the chairman of village committees) of the four villages were interviewed. It must be noted that, village is actually not an administrative level in China and therefore the village chief is not a government servant. Villages in China are self-governed by village committees, whose members are elected by villagers and held accountable to villagers and villager representative assemblies¹. In the four villages, 18 household head were interviewed to represent the local households. The interview targeted the household head as the person seen as knowing the most about his/her household. The interviews were conducted with single person and were held mostly in the offices or in the homes of the interviewees.

¹ Villages have been enfranchised under the Organic Law on Villagers Committees, passed by the National People's Congress in late 1987, which allows villagers directly elect committees to serve three-year terms and administer the village's affairs.

Net-Map interview	Policy makers	Provincial government	Forest department	1
		Prefecture government	Ningxia Forest bureau	1
		County government	Guyuan Forest bureau	1
			Guyuan Development and Reform Bureau	1
			Guyuan Financial bureau	1
			Guyuan Grain bureau	1
	Local agencies	Township government	Forest station chief	3
		Village	Village chief	4
	Farmers			18
		Total	31	

Table 2: Net-Map interview data

221 household surveys were conducted in the same three townships. 71 households in Xingsheng, 79 households in Huanghua and 71 households in Xiangshui were onsite sampled, which were approximately 8% of the households in the township (Table 3). The subjective impacts from interview, such as strategic answer, influence of the interviewer and misinterpretation, were seriously considered and carefully addressed. The Net-Map interview was conducted face-to-face by the first author and the household surveys were carried by a team led by the first author. Since 2014, this team has worked in Jingyuan County. The team included three PhD students from a research group in Institute of Geographic Sciences and Natural Resources Research (IGSNRR), Chinese Academy of Sciences. All team members were trained and well-prepared knowledge, enabling the interview to be conducted with minimum communication difficulty.

Township	Number of Household Net-Map	Number of Survey
Xingsheng	5	71
Hunaghua	8	79
Xiangshui	5	71
All	18	221

Table 3: Number of our sample township

Result

The results include two parts. The first part is the network derived from the Net-Map interview and the second part is based on the survey.

The Network of actors

Twenty-two most important actors have been identified by our 31 Net-Map sheets after concluding the interview process (Table 4). Multiple governmental agencies were involved in the implementation process and include departments from forestry and grain supply, to finance and development and reform commission (DRC). Agencies are tasked with releasing compensation in cash and grain, managing land contracts with farmers, mediating disputes, selecting and measuring land area for conversion, distributing saplings or grass species, issuing contracts, and monitoring results of conversion.

Actor	Abbreviation	Role	Orientation
State Forest administration	SFA	Policy makers	Forest governmental department
Province forest department	PF	Policy makers	Forest governmental department
Municipal forest bureau	MF	Policy makers	Forest governmental department
County forest bureau	CF	Policy makers	Forest governmental department
Township forest station	TF	Policy makers	Forest governmental department
Township chief	TC	local agencies	General administration
Village committee	VCO	local agencies	Non-government
Village chief	VC	local agencies	Non-government
Farmers	F	Practitioners	Non-government
Forest re-planting team	FRT	Practitioners	Non-government
Forest ranger	FR	Practitioners	Non-government
National development and reform commission	NDRC	Policy makers	Other governmental department

Provincial development and reform commission	PDRC	Policy makers	Other governmental department
Municipal development and reform commission	MDRC	Policy makers	Other governmental department
County development and reform commission	CDRC	Policy makers	Other governmental department
Central government	CEG	Policy makers	General administration
Provincial government	PG	Policy maker	General administration
Municipal government	MG	Policy maker	General administration
County government	COG	Policy maker	General administration
Bank	Bank	Practitioners	Non-government
Financial bureau	FB	Policy maker	Other governmental department
Grain bureau	GB	Policy maker	Other governmental department

Table 4: Actors in the network

The results show the network of actors for four different links, including task assignment, advisory, report and monitoring. In general, the perceptions of the network are varied between different hierarchies. Higher hierarchy level government can find more actors and their network are more complicated. As lower hierarchy as the actors are, they tend to know less. While the networks drawn by government are more complete, they are in line with their formal setting and their obligations. Different government departments (forest, finance, grain and DRC) are very careful to draw the network of others, as they do not want to have conflicts. The networks of the farmer look much simple. Since the information flow is top-down, the bottom actor naturally know less.

For visualization and detailed analysis, the information contained in the 22 Net-Map sheets was converted into 22 adjacency binary matrices to create the network graphs, in which information on the existence of a tie is coded with 1, and information on the non-existence of a tie is coded with 0 (Wasserman and Faust 1994). This was accomplished by summing up the adjacency matrices for each of the four links, resulting in four adjacency matrices, one for each links. For the analysis of this paper, we compared the network of policy makers, local agencies, and farmers respectively. The information about the importance, influence and motivation of the actor were listed in separate attribute tables.

For the visual interpretation, network graphs were generated using NetDraw. We used the actors' node shape to better visualise their roles. Policy makers were drawn as round, local agencies were drawn as square and triangle is practitioners. To visualise the role of the actors, we coloured the actors with regard to their orientation. Forest governmental department are coloured in green, general administration in blue, other governmental department in red and non-government in white. The thickness of the arrow represents the number for being mentioned by the 22 net-map interviews.

Figure 1, 2 and 3 are the network of task assignment for the three actor groups derived by UCINET. It is clear that policy makers have more complete network with 17 actors. The number of actors is reduced to 9 according to the perception of local agencies and most of them are below county hierarchy. Finally, the number is down to 6 at the household level and most actors are below township hierarchy. The complexity of the network and the richness of the information are depending on the hierarchy level. In general, the network of farmers is part of the network of local agencies, which is again part of the network of policy makers. Similar situations were observed in other links. In supplementary material, the network of advisory (Figure A4, A5 and A 6), monitoring (Figure A7, A8 and A9) and report (Figure A10, A11 and A12) can be found.

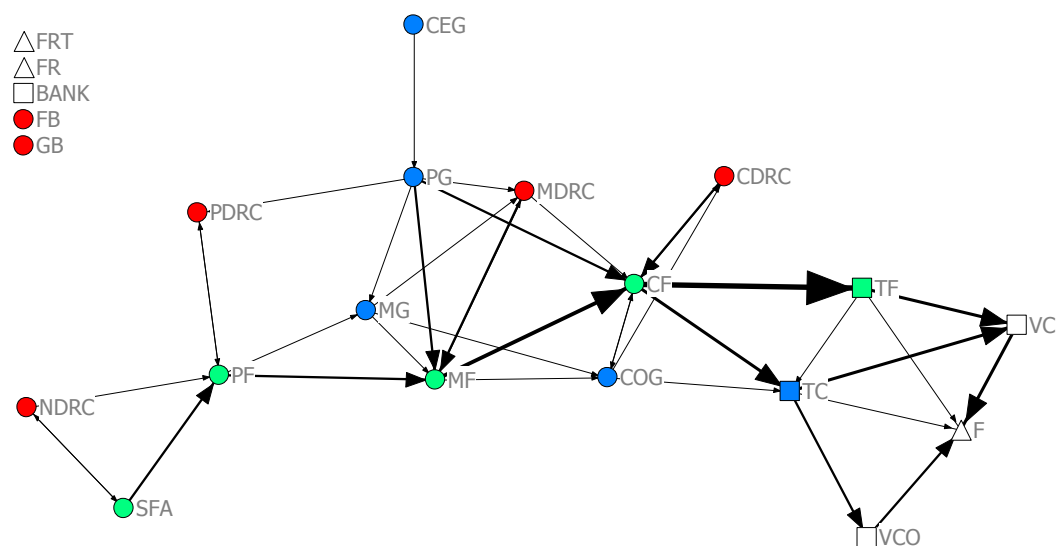


Figure 1: The Net-Map of task assignments from policy makers

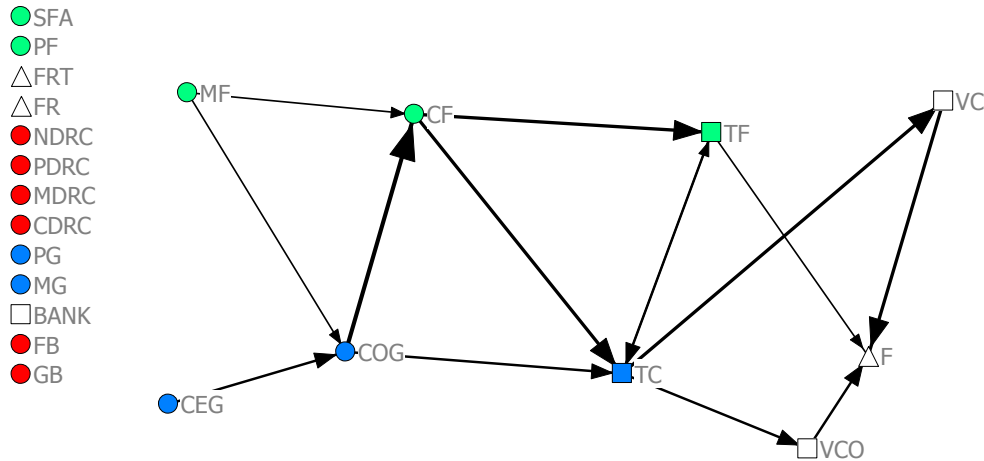


Figure 2: The Net-Map of task assignments from local agencies

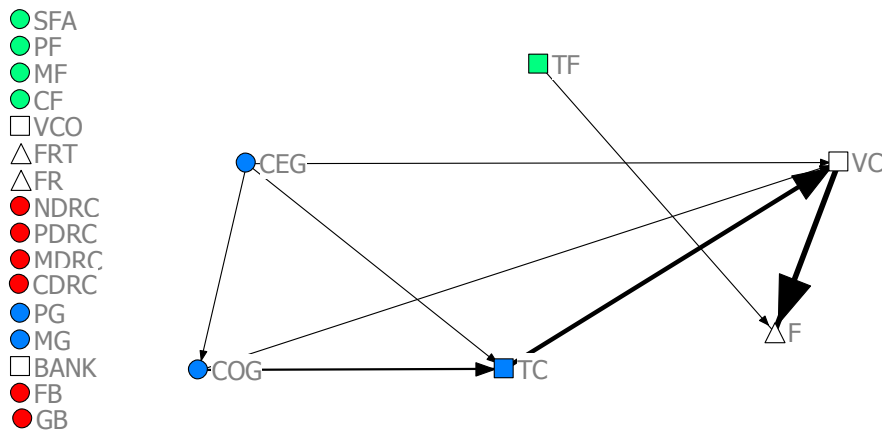


Figure 3: The Net-Map of task assignments from farmers

The network of four links all highlighted the important role of local agencies and farmers. The interview results have shown that local actors, such as village chief, village council and forest station are responsible for collecting and reporting information about local economic and ecological conditions, communicating higher directives to individual farmers, allocating reforestation quotas, calculating payments, providing technical supports and monitoring project implementation. Particular attention should be paid to the local governance models and interaction of local actors.

The importance of actors in the network

We calculated the actors' in-degree centrality and out-degree centrality for the network to determine the importance of actors. Degree centrality means the number of direct ties an actor has to other actors in a network (Wasserman and Faust 1994). In-degree centrality

means the number of direct incoming ties or the relations in which something is “received” by an actor (Wasserman and Faust 1994). Out-degree centrality is the reverse. Table 5 shows the in-degree and out-degree centralities in the network of four links, meaning that these actors maintain the highest number of relationships.

County forest bureau, township forest station, township chief, village chief and farmers are the most important actors in centrality analysis. Farmers have high in-degree centrality of task assignment, advisory and monitoring and out-degree centrality of report. This showed that the engagement of farmer is not as decentralized as the program should be.

	Task assignments		Advisory		Monitoring		Report	
	Out	In	Out	In	Out	In	Out	In
State Forest administration	2	1	0	1	3	0	0	1
Province forest department	3	3	1	1	0	0	1	1
Municipal forest bureau	3	4	3	1	0	0	2	1
County forest bureau	4	5	6	2	2	1	2	2
Township forest station	3	2	5	2	2	3	3	3
Township chief	4	4	3	2	2	0	3	2
Village committee	1	1	1	2	0	0	1	1
Village chief	1	4	2	3	1	1	3	5
Farmers	0	4	1	5	0	7	5	0
Forest re-planting team	0	0	0	0	0	0	5	2
Forest ranger	0	0	0	0	1	1	0	0
National development and reform commission	2	1	0	0	0	0	0	2
Provincial development and reform commission	1	2	0	0	0	0	0	0
Municipal development and reform commission	2	3	0	0	1	1	0	0
County development and	1	2	0	0	1	1	0	0

reform commission								
Central government	4	0	0	0	0	0	0	3
Provincial government	5	1	0	2	1	0	1	3
Municipal government	3	2	0	0	0	0	1	1
County government	4	4	0	1	1	0	2	2
Bank	0	0	0	0	0	0	0	0
Financial bureau	0	0	0	0	0	0	0	0
Grain bureau	0	0	0	0	0	0	0	0

Table 5 The result of centrality analysis

Survey result

We collected the data of SLCP implemented area of the three townships from the county forest bureau (Table 6). It has shown that three townships had implemented SLCP at different time and scales. For example, Xiangshui Township started SLCP relatively late and Xiangshui Township had more gradual steps.

Township	Village	2000	2001	2002	2003	2004	2005	2006
Xingsheng	Hongqi				1178.3		1101.6	
	Shangjing				214.8		1347.6	
Hunaghua	Shengli	1521.3				95.8	705.4	
	Miaowan		675.5	318.3	548		2270.8	
Xiangshui	Huitai	1500	690	689.8			1026.9	568.2

Table 6: 2000-2006 Jingyuan SLCP implemented area in our sample villages (unit: mu)

Our household survey revealed the overall implementation results of the three townships. The average cropland per households substantially decreased and forest and grass largely increased in all three villages. We asked the households to estimate the tree survival rate² of their SLCP enrolled land. The average in Xingsheng Township is up to 79.29%, which is close to the national standard of 85%. However, the average in Huanghua is only 54.05%.

² At the household level, the environmental effects were officially measured by the tree survival rate which counts the trunks 3–5 years after the saplings are planted.

Township	Cropland in 2013	Cropland in 1999	Forest and grass land in 2013	Forest and grass land in 1999	SLCP self-estimated tree survival rate
Xingsheng	6.58	10.62	4.45	0.24	79.29%
Hunaghua	5.53	12.62	7.25	0.15	54.05%
Xiangshui	4.34	12.85	8.68	0	72.22%

Table 7: Land areas in 1999 and 2013 in our sampled townships (unit: mu/household)

Our survey asked the households about their perceptions of local implementation. None of the three townships gave farmers the real autonomy (Table 8).

		County		
		Xingsheng	Huanghua	Xiangshui
Are you forced to join the project?	No	57.7%	58.0%	68.4%
	Yes	42.3%	42.0%	31.6%
Who decide which plot should grow trees?	Farmer	19.7%	27.8%	18.3%
	village chief	18.3%	29.1%	40.8%
	forestry station	7.0%	12.7%	14.1%
	higher-level government	54.9%	30.4%	26.8%
Can you receive the payment in time?	yes	75.7%	44.9%	59.4%
	most of time yes	11.4%	38.5%	14.5%
	no	12.9%	16.7%	26.1%

Table 8: Farmer perception about implementation

Discussion

We found farmers, village chiefs, forest station officials and local administration officials are very important for the implementation of SLCP. The local farmers are poorly informed and always lacking of influence. This study suggests that active household engagement is hard to achieve under a hybrid governance regime. Unlike policy designer thought, the decentralized power mostly goes to local government official rather than households.

Local governance model

Local institutional actors deserved a closer examination as they reflect local capacities, resources, and uniquely crafted SLCP implementation regulations. In order to integrate the central-designed approach specifically to the local social and ecological context, local institutional resources, including the involvement of local government agencies, village council (farmer councils), village chief, forest field station and farmer may be forced to coordinate and ideally deliberate the terms and conditions of implementation and management options. Three types of models for local governance have been observed in our Net-Map sheets in three different townships.

Xingsheng Township appeared to be the first type, where the executive actors (village chief and township chief) and forest actors (forestry bureaus or forest station) work separately with different tasks. The executive actors are in charge of coordination and communication and the forest actors are responsible for technical support and monitoring. However, the executive actors, not forest actors, take the primary responsibility in implementing the SLCP. They are expected to use all local resources to realize the goals of tree planting, forest management, and pass monitoring check. In contrast, the role of local forestry bureaus is reduced to a supporting party in the SLCP. In the network of Xingsheng Township, the interaction between village chief, forest station and farmers are one-way. As the two actors heavily rooted in bureaucratic incentives, they had hired a commercial re-planting team to fulfil the task. Local agencies were incentivized to focus on achieving the minimum goals of reforestation task with less concern on quality of the forest and the livelihood of farmers. Other studies also observed that local government took the parsimonious measures for SLCP in order to speed up the implementation, regardless of the conflicts with farmers (Yu 2016).

The SLCP is designed to have significant efforts for conflict resolving, appropriate reforestation land targeting, incentive creating. However, it was displaced by local governments to simply tree planting task. Therefore, we call this model of governance “task first”.

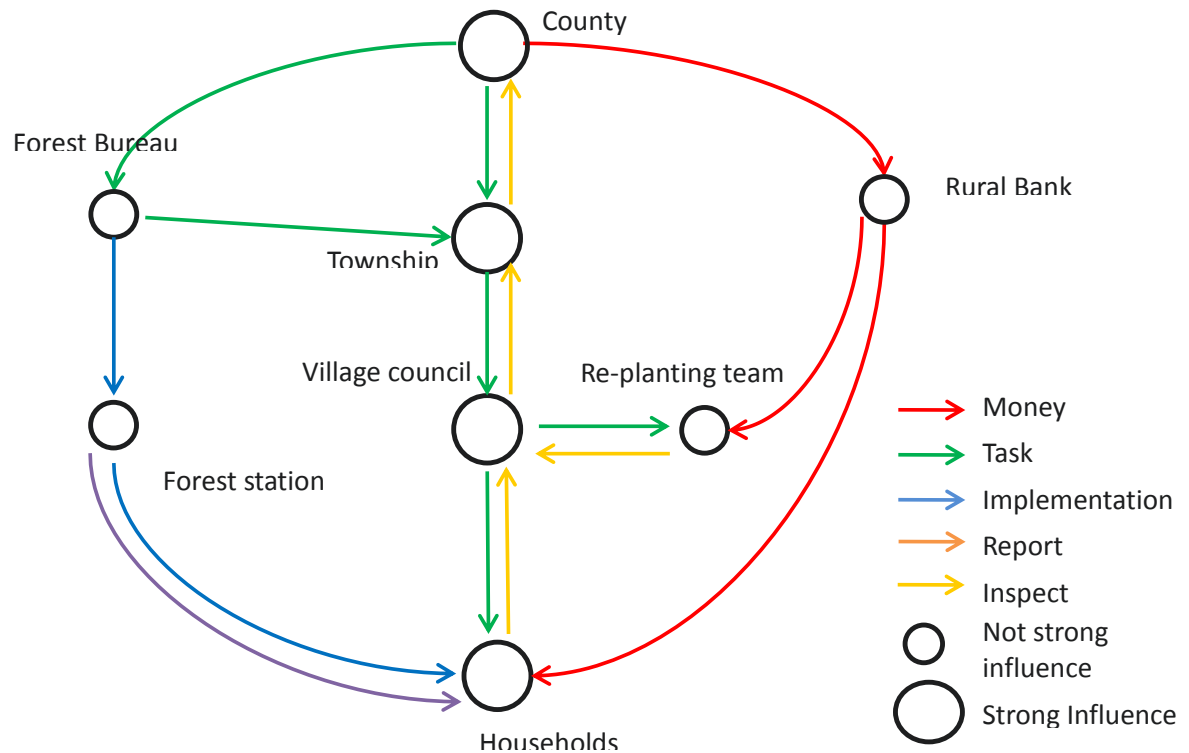


Figure 4: visualization of network of Xingsheng Township

Xiangshui Township tended to be the second type. On the contrary, the executive actors often closely work together with forest actors. There are cooperation between village chief and forestation. Some of their roles are overlapping and the interaction between village chief, forest station and farmers are often two-way. While the forest actors are in better position to make decision, the opinion of village chief and local farmers are taken into account. Locally embedded village council who provide trustworthy networks, information and assistance is considered as an active component within local governance structures. We call the model of governance “forest first”.

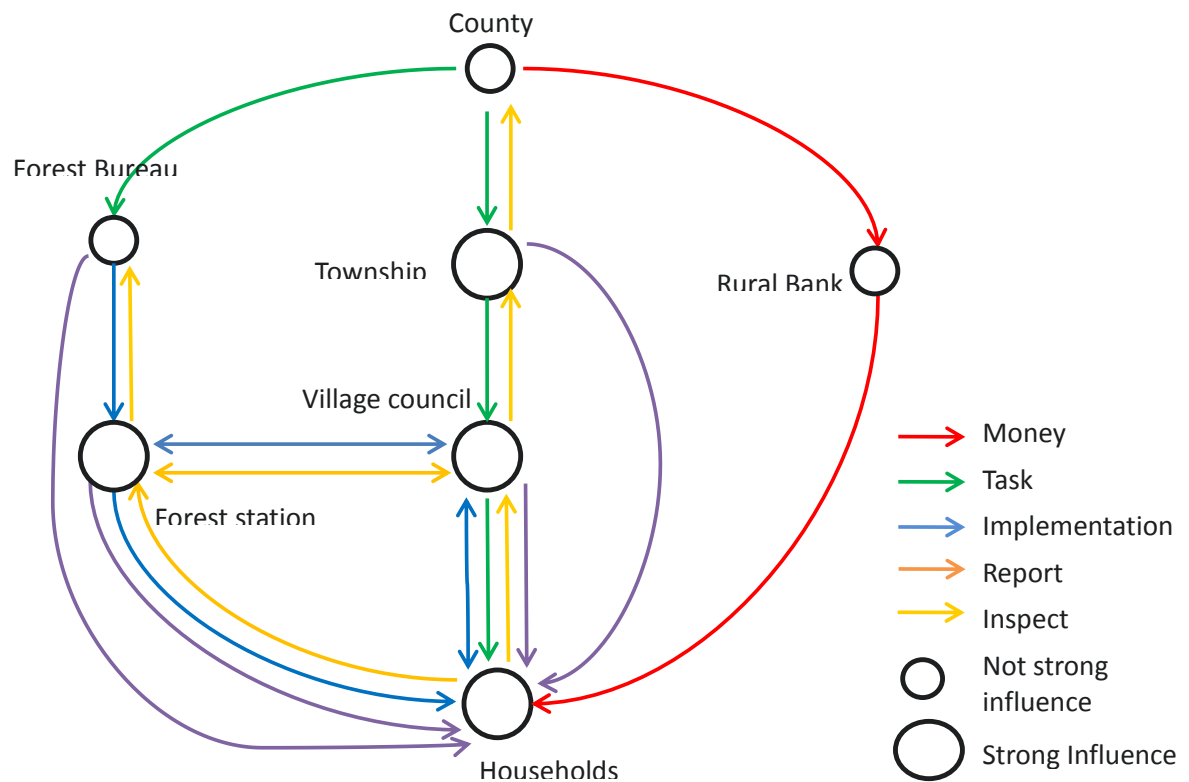


Figure 5: visualization of network of Xiangshui Township

Huanghua Township is something in between. The interaction between village chief, forest station and farmers are also one-way. As the technical support was jointly conducted by village chief and forest station, the forest station hold some influences on the village chief and farmers.

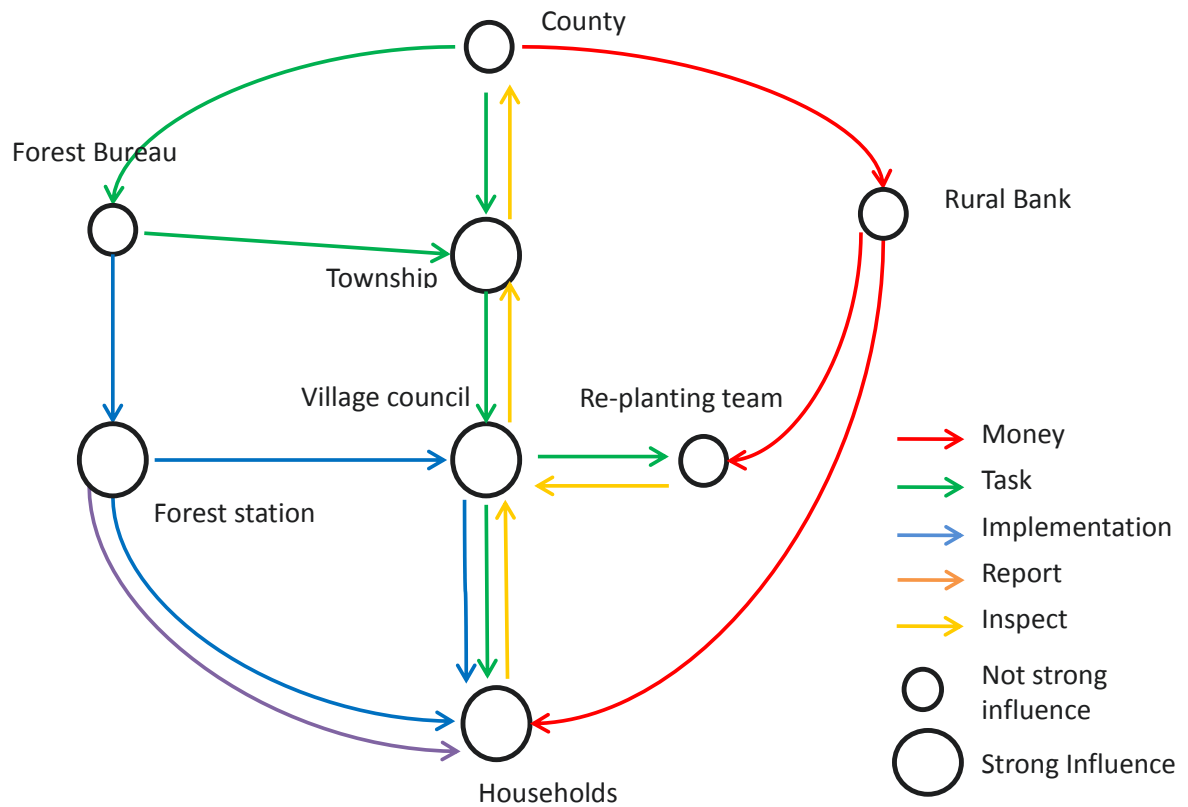


Figure 6: visualization of network of Huanghua Township

This collaboration between local actors at government, community and farmer and their motivations and interests for the implementation on the ground, play crucial roles. We developed a typology of local governance which assesses the Cooperation between executive and forest actors and farmer participation (Figure 7).

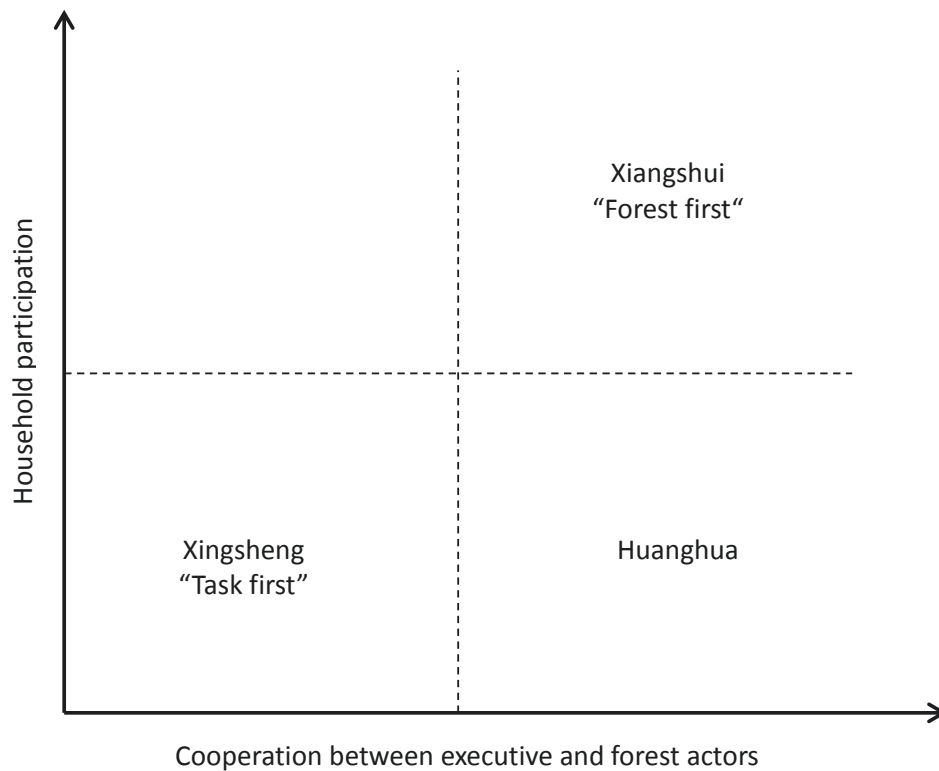


Figure 7: three types of models for governance at local level

Evidences support our framing for the three models. Xingsheng Township was in a rush for implementing SLCP. As shown in Table 5, Xingsheng Township had a late start but suddenly enrolled large amount of land in 2003 and 2005. This could be a large pressure for the local agencies and farmers. In order to fulfil this task, the local agencies had put speed over quality. On the contrary, Xiangshui Township started the program in 2000 and the enrolment took many years, allowing the local agencies to do it step by step and learn from past. Our household survey results are in line with the models as well. Xiangshui Township has the lowest rate for households being forced to join the SLCP. While the trust to the village chiefs was acknowledged by many households in Xiangshui Township, the village chiefs were considered as person who made final decision. Xiangshui Township had relatively high household self-estimated tree survival rate (Table 7), showing that this governance had a positive impact on environmental performance. Notably, Xingsheng Township had the highest self-estimated tree survival rate, which seemed contradict to our model. However, we do not think it is really a contradiction. The “task first” model does not necessarily mean bad environmental performance. Indeed, it can also achieve effectiveness when certain conditions are met. Another explanation is that this model gave too much

pressure to households, encouraging them to simply report success despite the failure. This was often observed in many other cases (Trac, Harrell et al. 2007).

New actor: Re-planting team

The showing up of 'replantation team' is an interesting phenomenon. Above county level, the higher level government didn't mention about this actor. On the local level, in Huanghua and Xingsheng Township, forest station and village chief mentioned this actor. Inappropriate choices of tree species were made in the first few years, given the study region's low water availability and harsh winter and re-planting was conducted every year to fill the gaps left by dead trees. Since many villagers left village to work in cities, they can't take care of their SLCP land. So, the village chief organizes people who still in the village to do the task and as return the so called 'replantation team' will get income cutting from the payments of original land owner who can't personally do the task. Years later, due to many rounds of re-planting, a mixed plantation of many indigenous species was established by the farmers. However, many farmers complained that their payment was greatly reduced due to the re-planting. While the re-planting may improve the environmental performance in the short-term, it cannot ensure the incentives for farmers to manage the land appropriately. It can twist the core of SLCP from incentive based approach to a subsidy program.

Governmental PES and the role of intermediary

Large-scale governmental PES programs have frequently been criticized for low levels of cost-effectiveness and environmental effectiveness. As low levels of cost-effectiveness is often the result of high transaction costs. Many studies argued that intermediaries within governmental PES governance structures can play an important role to facilitate transactions between governmental buyers and private sellers (Schomers, Sattler et al. 2015). Therefore, the involvement from intermediaries is considered to be helpful in reducing public and private transaction costs. Intermediaries can be from civil society (either individuals or non-governmental organisations), social entrepreneurs, non-for-profit actors, non-governmental organizations (NGO), governmental organizations and semi-governmental organizations. Unlike western countries, China does not have a very long history of participating with environmental NGOs and other social organizations for environmental interests, as western environmental movements are not the main driving force for ecological policy in China (Guttman, Young et al. 2018). Intermediaries from civil society (western-style environmental

NGOs, community groups and private consultancies) are not in place for ecological improvement in China. Therefore, the implementation of SLCP commonly depends on governmental organizations and semi-governmental organizations.

We found that the local cooperation between village council and forest station could potentially fill the role of intermediary in bringing together service beneficiaries and providers for up-front negotiation (local governance model of “forest first”, figure 5.). To maximize the advantage of PES idea, the government should take into account the importance of local engagement and facilitate information exchange among different stakeholders. We therefore argue that the local dynamics drive and shape the program implementation and particular attention should be paid to the interaction of local institutions.

Challenges in local governance

As the task and responsibility are not well defined, overlap and conflicts of local actors may cause substantial ineffectiveness of program implementation. Higher-hierarchy government (above county level) actors and lower-hierarchy actors have different views of actor's responsibility. For example, higher-hierarchy governments think in the local level, forest station in town are expected to mainly implement the SLCP through giving farmers the SLCP task, offering plantation technical support and in the end inspecting the outcome. However, people from forest station in town don't agree. They think village chief should do those work and their job is only guide farmer how to do SLCP (where to do and how). Furthermore, bureaucratic complexity and rent-seeking behavior could undermine the cooperation. Particularly, the tasks of SLCP are burdensome when local government agencies must pay the administrative costs from their own budgets. The rent-seeking behavior was reflected in the implementation, as local government agencies have found other ways to benefit from the system by increasing land conversion quotas, exceeding quotas and bargaining for more payments. As a result, local agencies view the SLCP payments as opportunities to finance their operation cost. Conflicts within the local cooperation were created when government agencies tried to minimize administrative costs by including parcels that are contiguous. If the negotiations between local actors can be improved and their role intermediary can be promoted, the environmental goals may be achieved in combination with greater self-interest of the actors at the local implementing levels (Kolinjivadi and Sunderland 2012). Therefore, policy maker of governmental PES should increasingly recognize and appreciate

the potential of local actors. A more explicit commissioning to the village council, local expert, cooperative and community as intermediary could be considered as an option for future policy.

Method advantages and limitations

Net-Map is powerful to distinguish the actors and how they acting with each other in a network. It can facilitate the interaction between interviewers and interviewees. Particularly, the interviewee can early understand the concept of mapping and can fully follow the process from the beginning to the end. It can be used to collect scientific data in the field, as it is a hands-on, low-tech and participatory tool. The method can be an “ice-breaker” to let the interviewee talk freely about the social network, especially informal one. It addresses several challenge for conducting interview, like reaching transparency, common understanding, easy-going atmosphere and the learning process (Schröter, Sattler et al. 2018).

However, there are limitations as well. Firstly, like many qualitative methods, it inevitably has a problem with subjectivity. The definition of the question needs to be explicitly clear. For example, the farmers were confused about the question “Do you know any actor involved in SLCP”. Are the actors they know personally or they know by name? Should they answer the questions according to they actually felt or they expected? Secondly, the network is based on perception and it may be deviated from reality. In this case, interviewee, like farmer and local government official, only can present a network they perceived rather than the full network they actually had. For example, the farmers have not mentioned central government in their network, although they got payments from the central. Instead, they claimed they got the money from the bank. Due to the lacking of knowledge, there were lots of missing puzzles in the farmers’ network. The farmers have difficulty to identify the actors above their hierarchy level. Thirdly, Over-simplification might be a problem as well. For example, our farmers told us the influence and importance tower are difficult. Particularly, the influence tower is not very reliable when the interviewee is evaluating the actor far away from their ordinary life. For instance, it is hard for the farmers to choose the influence tower of importance for the different governmental departments. Based on our experiences, Net-Map along cannot explain why the network appeared like this. As the interpretation of Net-Map rooted in qualitative information, the author needs to have an in-depth knowledge to make interpretation. Many supportive materials are needed for this

purpose. In our study, we had combined with descriptive statistic result. Other studies often had used qualitative materials, such as information from workshop (Schröter, Hauck et al. 2018).

To conducting a Net-Map interview is not easy, as it has high requirement for the interviewer. The interviewer needs to have the overview of the situation, be familiar with local knowledge and equipped with good communication skill to guide the interviewee. Finally, it is challenging in a closed and conservative cultural context and a top-down hierarchy institutional structure, such as in China and SLCP. The farmers in China are not used to openly discuss governmental policy and criticize the government. The duration of our interview with farmers is most of the time shorter than 30 minutes. On the contrary, the Net-Map interviews conducted by our colleagues Barbara in Costa Rica last in average one hour. Therefore, researchers have to consider the specific settings in the case study they want to investigate, especially regarding to power relations and distribution of knowledge. In contexts with strong hierarchies the method becomes more difficult to apply.

We also found UCINET cannot analysis the centrality and betweenness centrality for all links together. It always consider different link separately. The similar problem found in visualization as well. The network was displayed in different single link rather than in a combination for all (such as figure 4, 5 and 6). We cannot use UCINET to draw the figure of the three townships with all links.

Conclusion

In this study, we showed the importance of local actor in the network of a governmental PES and the effects of governance models on implementation. By using Net-Map, the actors' perceived network and the implementation of PES implemented at the local level were examined. The local farmers are poorly informed and always lacking of influence. Unlike policy makers thought, the decentralized power mostly goes to local agencies than householders. We found that the local agencies could potentially bringing together government and local farmers for up-front negotiations. However, local agencies could also violate the stated principals of volunteerism and replace the true farmer engagement in different governance model. Therefore, particular attention should be paid to the local governance models and interaction of local actors.

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Supplementary material

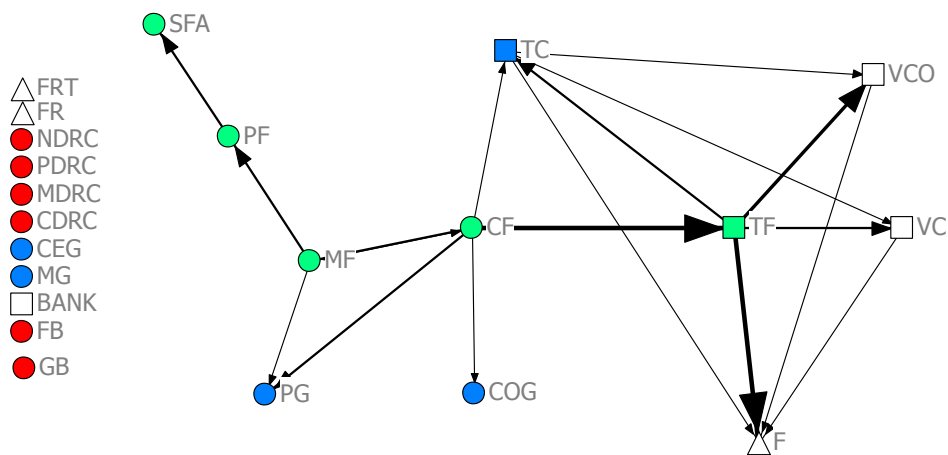


Figure A1: The Net-Map of advisory from policy makers

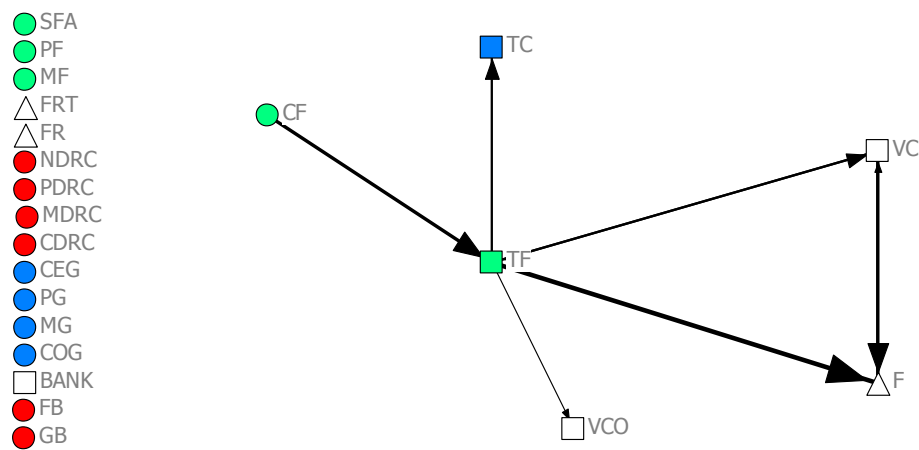


Figure A2: The Net-Map of advisory from local agencies

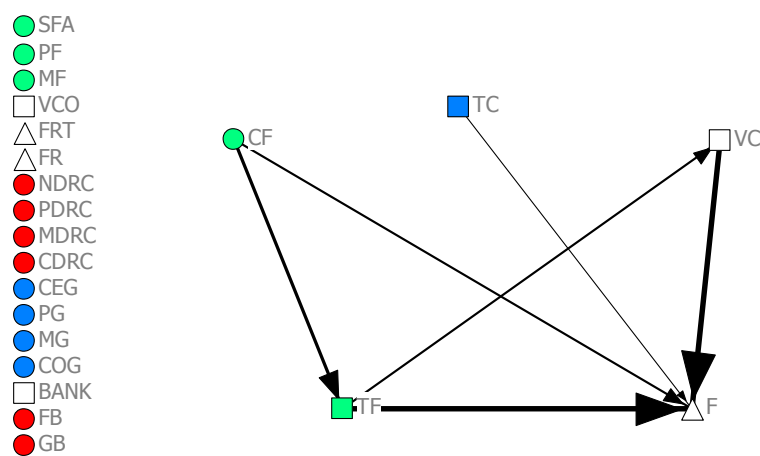


Figure A3: The Net-Map of advisory from farmers

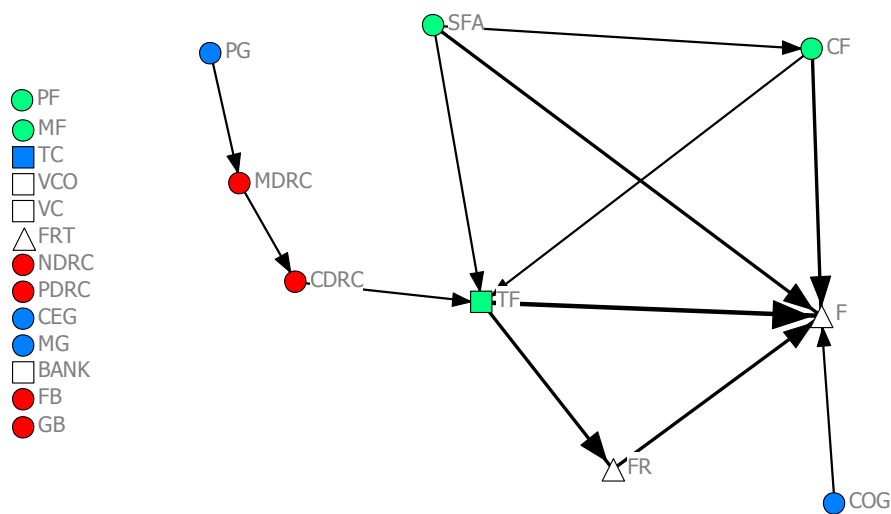


Figure A4: The Net-Map of monitoring from policy makers

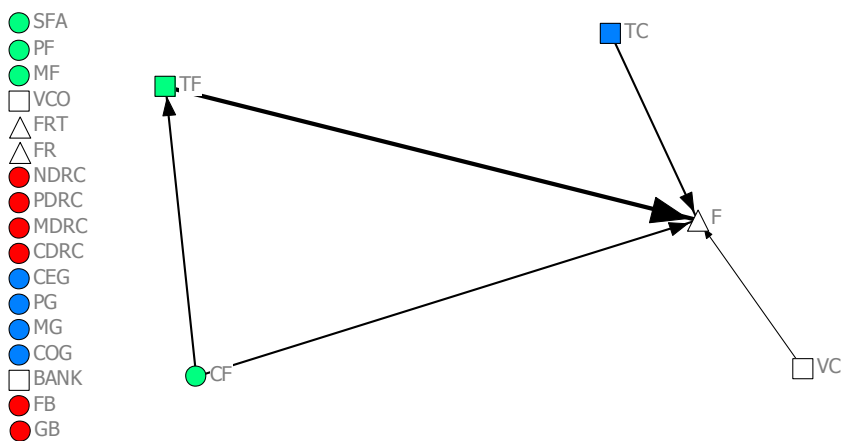


Figure A5: The Net-Map of monitoring from local agencies

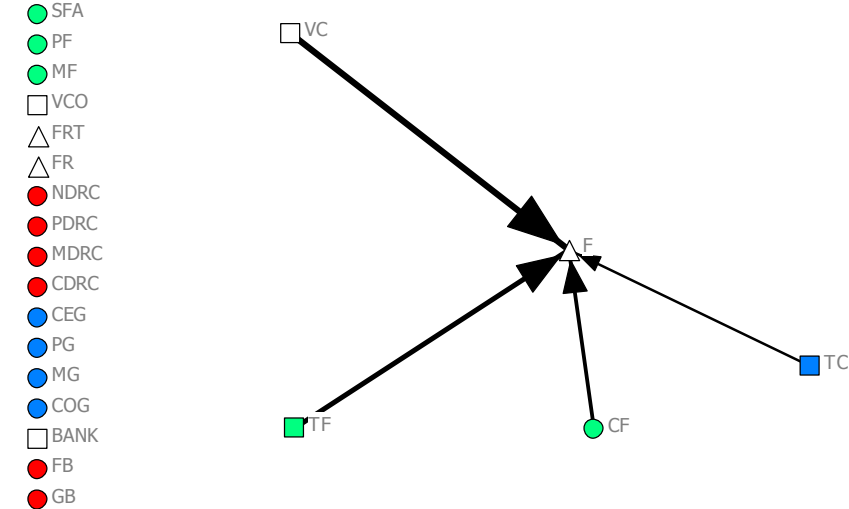


Figure A6: The Net-Map of monitoring from farmers

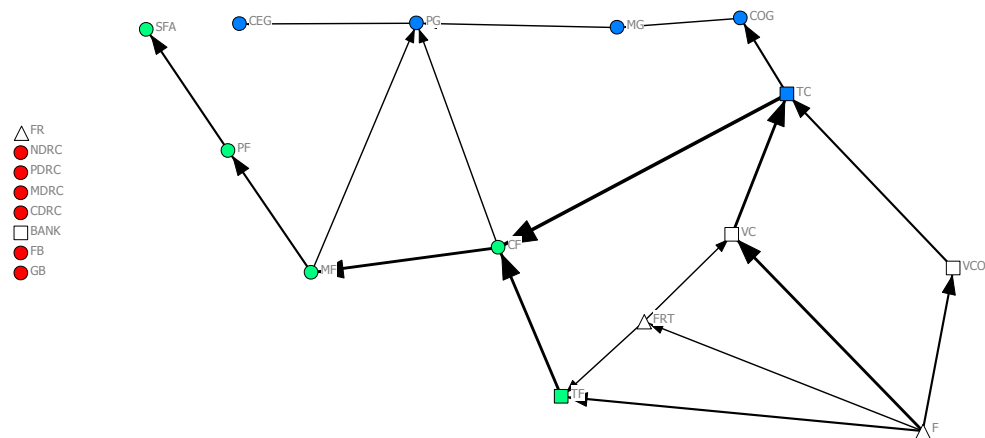


Figure A7: The Net-Map of report from policy makers

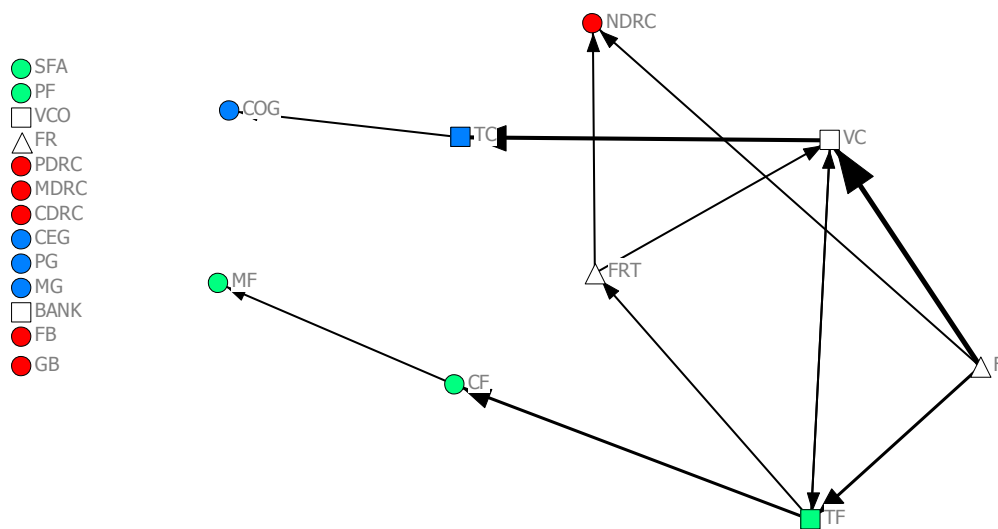


Figure A8: The Net-Map of report from local agencies

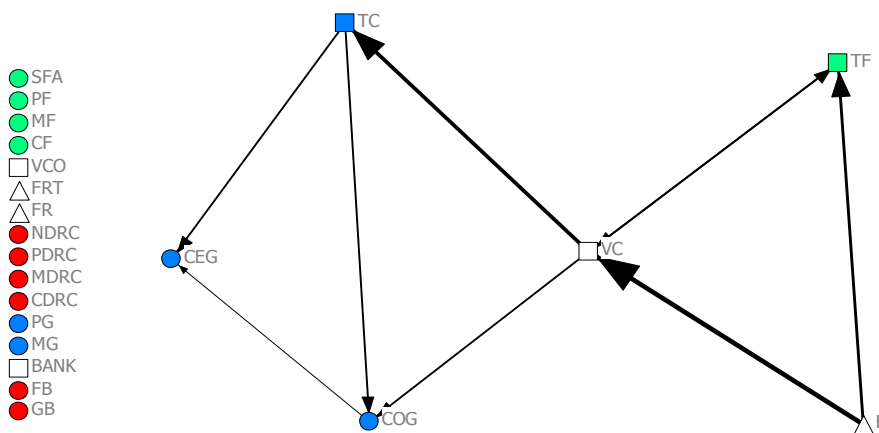
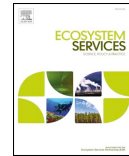


Figure A9: The Net-Map of report from farmers



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Qualitative comparative institutional analysis of environmental governance: Implications from research on payments for ecosystem services

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ABSTRACT

Designing environmental governance structures and in particular ecosystem services governance structures, means modifying, replacing, or creating institutional arrangements. Several scholars have tried to identify sets of functioning and particularly preferred institutional design principles for environmental governance. Comparative institutional analysis (CIA) plays a major role in this process and refers to comparing real-world institutions, organizations, decision-making structures, and coordination mechanisms. CIA attempts to determine preferred institutional arrangements among several possibilities. Within the paper, it is emphasized that the set-theoretic Qualitative Comparative Analysis (QCA) approach and technique may support CIA. Therefore, different institutional structures that regulate resource use may be understood and presented as sets of institutions and may be put into a relation. Correspondingly, the paper illustrates a qualitative comparative institutional analysis (QCIA) application procedure. It explains how QCA works, determines how it could be applied to CIA, and defines certain basic steps for QCIA application. The application of crisp-set and fuzzy-set QCA are presented step by step based on two examples – German agri-environmental payment schemes (AEM) and the Chinese Sloping Land Conversion Program (SLCP). Finally, challenges and benefits of QCA application to CIA of environmental governance structures are discussed. In sum, the paper shows that QCA may generally support the CIA of complex units, which are conducted by many institutional economists and institutionalists. QCA can help to facilitate the reduction of structural institutional complexity. Furthermore, QCA provides formalization for qualitative comparative aspects, and the generated results are highly policy relevant. However, there are certain challenges and limitations of QCIA that also cannot be neglected.

1. Introduction

Governance describes ruling and collective action (Benz et al., 2004). The concept can be referred to “steering”, involving elements of authority as well as processes and structures for shaping peoples’ priorities and coordinating peoples’ actions (Vatn, 2012). Governance depicts a dynamic interaction of actors and institutions (Borrás and Edler, 2012). Institutions are formal and informal rules defining policy processes, markets, and interactions in the civil society sphere,

including constitutional and collective choice rules, the rights to resources, the rules of interaction, and the norms of civil society (Benz et al., 2004). Thus, institutions are central to the analysis of environmental governance (Bromley, 1991; Hagedorn, 2000; Schlager and Ostrom, 1992; Vatn, 2005)². Environmental governance depends on various institutional structures that determine and regulate resource use at different levels and scales of socio-political organization (Berkes, 2002). Environmental governance and especially ecosystem services governance³ may furthermore imply formal and informal institutional

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² Within institutional economics there different schools and assumptions about individuals, behaviours, and the development of institutions differ. Our analyses are generally based on the economic institutionalist perspectives introduced by Vatn (2005, 2009) and Bromley (1989, 1990), who understand institutional change as instances of the social and political context rather than as results of utility maximizing, rational individuals.

³ Since early 90s there has been a shift in governance that is characterized by an emphasis on the important role that natural ecosystems play in economics as well as human wellbeing (Loft et al., 2015). Within this article ecosystem services governance is perceived as a mode of governance that largely draws on the relations and feedbacks between humans and the natural environment based on the ecosystem services concept (cf. Mann et al., 2015).

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development and change dependent on the social-economic-ecological context. The decision on distribution and redistribution of use rights to internalize certain externalities via agreements or government regulation may for example depend on the existing property rights situation as well as public perceptions of the environmental problem (Vatn, 2005).

Designing environmental and ecosystem services governance structures means modifying or replacing institutional arrangements if they are sources of a problem or creating incentives to cope with biogeophysical drivers if the problems are based upon those (see Young, 2002). Thus, generally, institutional arrangements are designed to meet a goal, “the solution of more or less well-defined problems” (Young, 2002: p. 17)⁴. Accordingly, institutional performance analysis identifies the extent of an institution’s contribution to achieving/not achieving a specific goal (Mitchell, 2008). An evaluation of institutional performance requires the definition of criteria against which the institution can be evaluated (Corbera et al., 2009). Several scholars have tried to compare sets of institutional design principles for collective natural resource management and to determine what works best (cf. Corbera et al., 2009: p. 745; referring to the principles developed by Agrawal (2002) and Ostrom (1990)). Monsees (2008) historically traces the development of such comparative institutional analyses (CIA) from first applications thereof by Demsetz (1969) to the approaches of Williamson (1991) and Frey (1984) and to complex concepts by Aoki (1996), and Buzbee (2000). CIA is defined very diverse and the different authors exercise various institutional analyses under this term. Thereby, CIA is taught and used not only by scholars in law and economics but across the social sciences (Cole, 2013). The central element is always a comparison of institutions, organizations, decision-making structures, and coordination mechanisms and judging them relative to one another. Thus, CIA attempts to determine preferred institutional arrangements among several possibilities (Monsees, 2008). Due to the complexity of socio-economic systems, there is mostly no overall best design solution with one governance approach as the main alternative. Rather, there are always trade-offs among different alternatives which may be adequate (e.g. Williamson, 1991, Aoki, 1996).

Consequently, for designing environmental and ecosystem services governance structures it is important to compare different institutional arrangements and to decide on potential alternatives. The comparison must be based on an ample knowledge on similar or different opportunities and the arrangement’s relationships as well as their trade-offs. The question arises how to compare the relevant institutional arrangements. We think that Qualitative Comparative Analysis (QCA), introduced by Ragin (1987), can be an adequate way to carry out CIAs, as the QCA idea meets central problems and demands of institutional economist and institutionalist approaches in terms of case-orientation, including qualitative data and small or intermediate numbers of cases as well as the focus on complexity and diversity (Ostrom, 1990, Aoki, 1996). Ragin (1987: p. 13) explains that when qualitatively oriented comparativists compare, “they study how different conditions or causes fit together in one setting and contrast that with how they fit together in another setting (...). That is, they tend to analyse each observational entity as an interpretable combination of parts – as a whole.” He emphasizes the idea of using set-theory⁵ for the interpretation and analysis of social science data in Qualitative Comparative Analysis (QCA) and presents the method in his book “The Comparative Method” (Ragin, 1987). QCA is building upon causal interpretation, visualization, and analysis of

causal complexity as well as principles of logical minimization. Interest in QCA has grown in recent years because of fundamental debates on empirical social science methodology in comparative social science (Schneider and Wagemann, 2012)⁶. QCA is often presented as a third way between quantitative statistical techniques and case-study methodology (Ragin, 1987) and combines an established subfield in mathematics and social sciences principles and practices. The final analyses consist of conditions that are subsets of the outcome and are thus sufficient and/or necessary (Schneider and Wagemann, 2012). Thus, QCA is not only a data analysis technique but also a research approach including the processes before and after the analysis of the data, such as the collection of data, definition of case studies, and specification of concepts (Rihoux and Ragin, 2009).

In sum, we understand that QCA may be valuable to support CIA regarding the determination of potentially adequate institutional arrangements because institutional arrangements often may be presented as sets of institutions and be put into a set relations. Furthermore, QCA was originally developed to formalize qualitative comparative methods (cf. Ragin 1987) and is suitable to intermediate number of cases (5–100) (Ragin, 2000: p. 25, see also Schneider and Wagemann, 2012). Recently, there have been first applications of QCA in institutional environmental governance analysis (e.g., Meyer et al., 2015; Hamidov et al., 2015; Pahl-Wostl and Knieper, 2014; Bodin and Österblom, 2013; Basurto, 2013; Chen et al., 2018). However, existing literature focusses either on QCA case study applications to institutional environmental governance structures, or else, on a QCA application in general, in terms of method papers, textbooks, and handbooks (e.g. Schneider and Wagemann, 2012; Berg-Schlosser and Cronquist, 2012). A QCA application to CIA of environmental governance structures has not been specifically worked up and methodologically systematized so far. Accordingly, within this method-illustrating paper we aim to systemize the qualitative comparative institutional analysis (QCIA) application procedure and discuss the suitability of the approach and technique, based on the application of QCA to two CIAs on governmental payments for ecosystem services (PES). Thus, we choose two governmental PES implemented in very different social-cultural, socio-economic, and political contexts. By deriving the systematization of the method’s application from cases in different contexts we aim at ensuring a good transferability of the developed application systematics. Furthermore, the two different examples reveal the two main QCA variants which should be both covered by the systematics. The additional value of the paper over existing text books as well as general method and research papers is a straight forward guideline on how to use QCA for CIA of environmental and ecosystem services governance structures, especially on PES. Furthermore, potentials as well as limitations of an application to CIA are firmly explained. In sum, the objectives of this method-illustrating paper are:

- Systematization of a QCIA application to environmental governance structures: Step-by-step guidelines
- Presentation of the step-by-step application to two different PES governance structures
- Discussion of QCA’s suitability for CIA of environmental and ecosystem services governance structures

Therefore, in Section 2, we explain how QCA works, determine how it could be applied to CIA and define certain basic steps for application. In Section 3, we illustrate two different applications of QCIA step by step: The application of crisp-set QCA to the institutional analysis of German agri-environmental payment schemes (AEM), basically governmental agreements with farmers to adopt predefined practices or to

⁴ In the course of designing environmental governance structures we kept in mind that only some institutions can be designed and the institutional context always matters. Thereby, institutions do “not only define the social environment within which the individual is choosing. They also constitute the individuals themselves and their interest.” (Vatn, 2005: p. 61) Aspects of an informal institutional context may also be included in comparative qualitative institutional analysis if relevant.

⁵ Set-theory is the mathematical theory of well-determined collections (sets) of objects (members or elements of the set) (Bagaria, 2017).

⁶ Schneider and Wagemann (2012) understand QCA as the most formalized and complete set-theoretic method. They provide a graphical overview on different set-theoretic approaches in social sciences and their relation to other empirical comparative approaches (Schneider and Wagemann, 2012: p. 10).

provide predefined ecological conditions for payments compensating them for additional costs and loss of income (Mettepenningen et al., 2009; Uthes and Matzdorf, 2013), and the application of fuzzy-set QCA to the institutional and social analysis of the Chinese Sloping Land Conversion Program (SLCP), a forest restoration program where participating households received payments in the form of grain or cash for converting cropland on steep slopes to forest or grassland (The State Council, 2002). In Section 4, we discuss the presented cases and the applicability of QCA to the CIA of environmental and ecosystem services governance structures in general and show strengths and weaknesses. Finally, in section five, we conclude.

2. Qualitative comparative institutional analysis

In a first step we will show how QCA works and in a second step we relate QCA to CIA. QCA is understood as a middle way that combines certain features of qualitative research (e.g. case orientation) with features of quantitative research (e.g. the interest in generalization) (Sehring et al., 2013). QCA aims to find matches of cases' properties and a common outcome in a formal way (Berg-Schlosser and Cronquist, 2012), or, in other words, to determine subset relations between certain variables and an outcome (Ragin, 1987, 2008). Thereby, QCA is not following a statistical logic but employs set theory, the logic of prepositions, Boolean algebra, and fuzzy algebra (Schneider and Wagemann, 2012). The method focusses the understanding of the relations between different causes and how they are interconnected in a certain context (Rihoux and Ragin, 2009). Basic QCA ideas are the application to intermediate numbers of cases (5–100) that are too small for statistical analysis and systematic cross-comparison while they are still case sensitive. A central principle is multiple conjunctural causation, which means that not only single variables but combinations of variables can (and most often will) lead to an outcome, that different combinations of variables can produce the same outcome, and, that one

condition can have different impacts on the outcome, depending on the combination with other factors (Sehring et al., 2013). Another main concept is the idea of sufficiency and necessity. It reveals that condition can be interpreted as necessary if in the case that the outcome is present, the condition is always also present. On the other hand, a condition can be interpreted as sufficient in the case that if the condition is present, the outcome is always also present. The necessary condition is a super-set of the outcome, while the sufficient condition is sub-set of the outcome (Schneider, 2009; Schneider and Wagemann, 2007). Generally, necessary conditions are a bold statement and rarely found empirically (Schneider and Wagemann, 2007).

For QCA application we draw back on two text book examples showing the two different main variants of a QCA application: Crisp-set QCA (csQCA) (see Box 1) and fuzzy-set QCA (fsQCA) (see Box 2). The two main QCA variants differ in types of sets on which they operate: CsQCA operates on sets where cases can either be members or non-members with membership scores 0 or 1. In fsQCA, cases are allowed to have gradations of their set membership. The application of the one or the other variant depends primarily on the existing detailedness of information regarding variables and outcome. QCA operations include negations/complements of the case sets NOT (–), the logical AND (*) to bring together two or more single sets into conjunction, and the logical OR (+) to describe a union of different case sets, encompassing elements belonging to either one case set or the other or both (Schneider, 2009). The information for the cases is presented in truth tables in which each row displays one of the 2^k logically possible combinations of variables (k) and the observed outcome value of the cases that depict one of the 2^k variables (Schneider, 2009; Schneider and Wagemann, 2007). Cases having the same conditions and outcome are presented in the same row of the truth table and are analytically identical. The truth table shows under which combination of conditions a certain outcome occurs or does not occur.

Box 1

The Kindergarten example - formal analysis of sufficiency in csQCA (adapted from Berg-Schlosser and Cronquist, 2012: pp. 138)

In a hypothetical case, the parents of a four-year-old boy are surprised at the desired guests for their son's birthday party. Thus, the example's outcome is a party invitation or non-invitation. The parents assume that reasons for invitation could be the membership in the son's Kindergarten-group (K-group), the age of the children (older kids preferred) and the gender. They look at data of five invited a three non-invited children:

Names (cases)	Conditions K-group (yes: 1, no: 0)	Age (>4 years: 1, ≤4 years: 0)	Gender (girl: 1, boy: 0)	Outcome Invited (yes: 1, no: 0)
Peter	0	0	0	0
Cindy	0	0	1	1
Ian	0	1	0	0
Betty	0	1	1	1
Michael	1	0	0	0
Paula	1	0	1	1
Adam	1	1	0	1
Jane	1	1	1	1

An example for a proposition from the table: Betty is a girl who is older than four and is not in the son's Kindergarten-group ($\sim K\text{-group} * \text{Age} * \text{Gender}$). Now, which individual conditions are sufficient for the outcome "Invited" are checked – meaning that wherever the condition occurs, the outcome should also occur. Neither all kids from the K-group nor all older kids (Age 1) are invited. Thus, the K-group and Age alone are not sufficient conditions. However, all girls (Gender 1) are invited to the party. Thus, gender is sufficient for the outcome. However, this does not fully answer the parents' question as in addition to the girls, the boy Adam is also invited. Therefore, combinations of conditions are applied. The AND conjunction for K-group and Age fulfils the criterion of sufficiency, meaning that all kids older than 4 (Age 1) who are in the same Kindergarten-group (K-group 1) are also invited. The parents now can explain the invitation behaviour of their son and the sufficient conditions for invitation. It is sufficient to be a girl or an older kid from the son's Kindergarten-group ($\text{Gender} + K\text{-group} * \text{Age} \rightarrow \text{Invitation}$).

Table 1
Assumed and coded rules for successful AEM (adapted from Meyer et al., 2015: p. 150).

No.	Design rule	Presence	Definition	Labels	Code
1	Ecosystem service targeting	yes	AEM focusses on one primary environmental objective	ESTARGET	1
		no	Different environmental objectives	~ ESTARGET	0
2	Area targeting	yes	AEM has to be applied to certain area, or it protects a certain habitat	AREATARGET	1
		no	Flexible application	~ AREATARGET	0
3	Flexibility in application	yes	Farmer has individual flexibility in technical, temporal, or area wise AEM application	FLEXIAPP	1
		no	Flexibility is lacking	~ FLEXIAPP	0
4	Nature protection agency involved in implementation	yes	The nature protection agency obligatorily participates in AEM implementation	IMPLNAT	1
		no	If not	~ IMPLNAT	0
5	Access to advice	yes	The administration takes care of the advice, or a reliable advice service exists for AEM	ADVICE	1
		no	If not	~ ADVICE	0

^aThe capital labels explain the presence of a variable (1), lowercase labels explain its absence (0).

Table 2
Truth table for AEM application (adapted from Meyer et al., 2015: p. 157).

Row	Conditions ^a					Number	Outcome Success ^b
	ESTARGET	AREATARGET	FLEXIAPP	IMPLNAT	ADVICE		
1	1	0	1	1	0	1	1
2	1	0	1	0	0	2	1
3	1	1	0	1	1	3	1
4	1	1	1	0	1	1	1
5	1	1	1	1	1	12	1
6	1	0	0	0	0	2	0
7	0	0	0	0	1	2	0
8	0	0	0	0	0	3	0
9	0	0	1	0	0	8	0
10	1	0	1	0	1	5	0
11	1	0	0	0	1	2	0
12	0	0	1	0	1	2	0
13	1	0	0	1	1	1	0
14	1	1	0	0	0	1	0
15	1	1	0	0	1	1	0
16	0	1	0	1	1	3	0

^a ESTARGET: Ecosystem service targeting, AREATARGET: Area targeting, FLEXIAPP: Flexibility in application, IMPLNAT: Nature protection agency involved in implementation, ADVICE: Access to advice.

^b Set at consistency 0.74 cutoff due to natural break in data.

Within the csQCA example (see Box 1) we show how QCA draws on set memberships to generalize the information of different cases in terms of three conditions K-group, age, and gender. We also demonstrate that csQCA requires dichotomization of data, which is sometimes not easy to achieve as certain social science concepts require detailed and nuanced information (Schneider and Wagemann, 2012). Therefore, csQCA has been increasingly criticized. However, the newer and recently more often applied fsQCA variant offers a qualitative distinction between cases and adds “differences in degree” to “differences in kind” which are provided by crisp-sets (Schneider and Wagemann, 2012: p. 14).

As mentioned above, in contrast to crisp-sets, fuzzy-sets allow for partial membership in a set. The elements could be, for example, fully in (1), mostly in (0.8), crossover – neither in nor out (0.5), mostly out (0.2), etc. (Ragin, 2000: p. 156). Such partial membership values require different forms of presentation. Ragin (2000) suggests

an XY plot of which the axes show the fuzzy-set membership scores of the cases in the set of condition X and the outcome Y. For sufficiency, each case’s fuzzy-set membership score in X must be equal to or smaller than its fuzzy-set membership in Y. In an XY plot, this dynamic is visualized by drawing a diagonal. X is a subset of Y if all cases fall above the main diagonal. As the basic sufficiency requirements are the same for crisp and fuzzy-sets, the sufficiency analysis looks generally identical. To be sufficient, the membership of each case/row in the condition must be equal or smaller than its membership in Y. In fsQCA a possible necessary condition is signaled when instances of the outcome Y constitute a subset of instances of a condition X. We show an example of an fsQCA application using a hypothetical example adapted from Schneider and Wagemann (2012: pp. 67) in Box 2.

Box 2

The *Stable Democracy* example – formal analysis of sufficiency in fsQCA (adapted from Schneider and Wagemann, 2012: pp. 67)

In a hypothetical case, researchers are interested in the conditions for a stable democracy in selected Latin American countries. The researchers assume that three aspects could play a role in stable democracies (DEM): Violent upheavals in the past (condition: UPH), an ethnically homogeneous population (condition: POP), and a pluralistic party system (condition: PAR). The researchers included 10 Latin American countries in the example. They have already dichotomized (1/0) the data and conducted a csQCA, achieving the result of an absence of a violent upheaval or an ethnically heterogeneous population in combination with a pluralistic party system ($\sim \text{UPH} + \sim \text{POP} * \text{PAR} \rightarrow \text{DEM}$). The fuzzy-set membership scores are presented the following matrix:

Rows	Cases	Conditions					Outcome	
		UPH	POP	PAR	$\sim \text{UPH}$	$\sim \text{POP} * \text{PAR}$	DEM	$\sim \text{DEM}$
1	Argentina	0.8	0.9	1	0.2	0.1	0.1	0.9
2	Peru	0.7	0	0	0.3	0	0.2	0.8
3	Bolivia	0.6	1	0.1	0.4	0	0.3	0.7
4	Chile	0.3	0.9	0.2	0.7	0.1	0.6	0.4
5	Ecuador	0.9	0.1	0.3	0.1	0.3	0.4	0.6
6	Brazil	0.2	0.8	0.9	0.8	0.2	0.7	0.3
7	Uruguay	0.9	0.2	0.8	0.1	0.8	0.8	0.2
8	Paraguay	0.2	0.3	0.7	0.8	0.7	0.9	0.1
9	Columbia	0.2	0.4	0.4	0.8	0.4	1	0
10	Venezuela	0.9	0.7	0.6	0.1	0.3	0.3	0.7

The fsQCA sufficiency analysis was only performed for the conditions that turned out to be sufficient in the csQCA: $\sim \text{UPH}$ and $\sim \text{POP} * \text{PAR}$. The fuzzy value of $\sim \text{POP} * \text{PAR}$ is always less than or equal to the fuzzy value of the outcome. The fuzzy value of $\sim \text{UPH}$, however, does not pass the test based on fuzzy sets. Various cases/rows show a higher membership score in $\sim \text{UPH}$ than in DEM. The XY plots visualize these findings: $\sim \text{POP} * \text{PAR} \rightarrow \text{DEM}$.

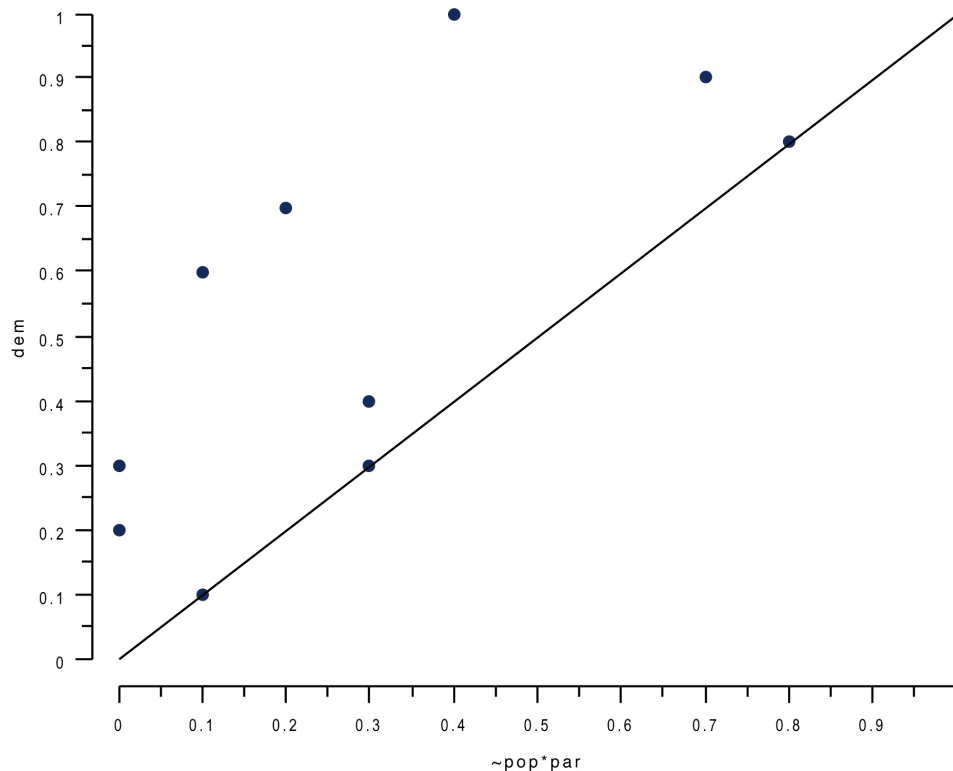


Table 3
Definition of conditions in SLCP application (adapted from [Chen et al., 2018: pp. 31](#)).

Condition	Presence	Definition
Household involvement (INVO)	1	Household is fully involved in decision making.
	0.8	Household is mostly involved in decision making and feels satisfied about the result.
	0.6	Household is mostly involved in decision making but feels unsatisfied about the result.
	0.4	Household is partly involved in decision making and feels satisfied about the result.
	0.2	Household is partly involved in decision making but feels unsatisfied about the result.
	0	Household is not involved in any decision making.
Property rights (PROP)	1	Household has strong recognition of the property rights.
	0.67	Household recognizes the property rights.
	0.33	Household hardly recognizes the property rights.
	0	Household recognizes no property rights.
Off-farm labor allocation (OFF)	1	Great majority of income comes from off-farm employment.
	0.67	A large part of income comes from off-farm employment.
	0.33	A small part of income comes from off-farm employment.
	0	Household is not engaging with off-farm employment.
Effective monitoring (MONI)	1	The monitoring works effectively.
	0.67	The monitoring works.
	0.33	The effect of monitoring is poor.
	0	The monitoring does not work.
Financial incentive (FINA)	1	Payment is very attractive given the responsibility
	0.67	Payment is attractive given the responsibility
	0.33	Payment is very little attractive given the responsibility
	0	Payment is not attractive given the responsibility

For an application of QCA to CIA, the comparison of institutional arrangements must be presentable in terms of set relations. Thus, different possibilities of institutions, organizations, decision-making structures, or coordination mechanisms must be described as related sets. The requirement of framing institutional arrangements in terms of set relations corresponds to the general prerequisites of CIA to present consistent sets of characteristics for the definition and description of all compared institutional arrangements ([Monsees, 2008](#)). Correspondingly, a general compatibility of the QCA and CIA can be affirmed. Furthermore, the original goal of QCA development is a formalization of qualitative comparative methods without departing from the general logic of case-oriented research. Ragin emphasizes that “...*qualitative researchers tend to look at cases as wholes and they compare the whole cases with each other. Cases are viewed as configurations – combinations of characteristics*” ([Ragin, 1987: p. 3](#)), and he understands that in such case study approaches, it is often difficult to examine more than a few cases when confronted with a large number of cases in which the investigator has to make many paired comparisons and in which “...*the analysis may disintegrate into descriptive statements lacking any generality*” ([Ragin, 1987: p. xiii](#)). This initial idea exactly meets central issues and demands of institutional economist because institutional approaches are often case-oriented, include qualitative data, are based on datasets with small or intermediate numbers of cases, and highlight the complexity, diversity, and uniqueness of certain institutional arrangements (see e.g. [Ostrom, 1990; Aoki, 1996](#)).

Many institutional economist and institutionalist approaches use complex structures as units of analysis (including for example various rules, actors, and relationships) and aim at finding fitting governance structures for different transactions ([Monsees, 2008](#)). Such demands may be met (at least partially) by QCA's focus on multiple conjunctural causation. Combinations of relevant structural elements may for example be analyzed in terms of their conjunctural fit. Different combinations of certain structural elements may be relevant for the same outcome but also same structural elements can be analyzed for different impacts within different complex situations. However, applying QCIA and presenting institutional arrangements as set relations means reducing the structural institutional complexity as well as targeting only one function of the governance structure by using only one output variable. Institutional complexity reduction can be implemented through stylization ([Ostrom, 1990; Williamson, 1991](#)). Regarding [Monsees \(2008\)](#),

this process could be, for example, a choice of the most frequent, differing types of institutional arrangements from a total of cases and, in a second step, the elaboration of the prototypical characteristics of the main types. Determining the one output variable may be based on comparison and assessment criteria in terms of type and quality, e.g., certain qualitative efficiency criteria. [Monsees \(2008: p. 16\)](#) reviews a variety of criteria sets for comparative institutional analysis and summarizes different clusters, as adaptability, efficiency, externalities, fairness, production costs, accountability, and transaction costs.

Based on CIA requirements and QCA opportunities, we emphasize five steps for QCIA application, the determination of sufficient and necessary conditions, and the definition of preferred institutional arrangements. In step 1, it has to be clarified whether the institutional arrangements to be compared may be presented as set relations with regard to an output. Therefore, it has to be checked whether the institutional complexity could be reduced and, correspondingly, conditions have to be selected. In step 2, one output variable has to be specified by fixed, measurable criteria. In step 3, the transformation of qualitative or quantitative data into crisp or fuzzy-sets should be applied. A calibration technique is needed to make the process transparent and replicable. Step 1–3 may be dynamically related to the data collection processes. In step 4, the analysis for necessary and sufficient conditions has to be conducted. Finally, in step 5, a case-based examination of the inconsistencies (not successful cases included in the solution terms) and non-coverage (successful cases not included in the solution terms) should be done for solution term verification and generalization. The application of the five different steps will be exemplified and explained in detail within the next Section 3. For illustration we draw back on QCIA application to two PES governance structures.

3. Application of QCIA to PES governance structures

The illustrative QCIA have been applied to governmental PES in Germany (Agri-environmental measures, AEM) and China (Sloping Land Conversion Program, SLCP). The PES concept is diversely defined, and the term has been used to refer to various national conservation approaches that create positive economic incentives for the provision of ES worldwide (cf. [Muradian et al., 2010; Vatn, 2010](#)). [Corbera et al. \(2009: p. 745\)](#) understand PES as “... *new institutions designed to enhance*

Table 4
Sufficient conditions for success of AEM (adapted from Meyer et al. 2015: p. 151).

Term		Cases
1	ESTARGET*AREATARGET*IMPLNAT*ADVICE	15
2	ESTARGET*AREATARGET*FLEXIAPP*ADVICE	13
3	ESTARGET*~AREATARGET*FLEXIAPP*~ADVICE	3

Success = f(ESTARGET, AREATARGET, FLEXIAPP, IMPLNAT, ADVICE) Consistency cutoff: 0.750000.
Solution coverage: 0.727273, solution consistency: 0.842105.

or change natural resource manager's behavior in relation to ecosystem management through the provision of economic incentives". Such broad PES idea incorporates hybrid governance structures, including hierarchies as well as market concepts (Matzdorf et al., 2013; Vatn, 2010), and state rules play major roles in such PES governance structures (cf. Matzdorf et al., 2013). Thus, the definition includes the large governmental payment schemes (as German AEMs and the Chinese SLCP). While these schemes rely on incentive-based mechanisms and voluntary participation (State Forest Administration 2007 for SLCP) they also include traditional hierarchical elements, such as a top-down structure, inflexible contract design and campaign-style mobilization (Kolinjivadi and Sunderland, 2012).

AEM are basically governmental predefined agricultural management practices which are environmentally favorable and can be taken up voluntarily, often with certain different options for application. The government, as a representative of the public, pays the farmers for application in terms of additional costs and loss of income (cf. Mettepenningen et al., 2009). German AEM are either co-developed and co-financed by the EU and German federal states within the framework of the European Common Agricultural Policy (CAP)⁷ or developed and financed solely by the federal German states (cf. Kirschke et al., 2007). EU expenditures on AEM have been significant, amounting to nearly 20 billion EUR for the period from 2007 to 2013 (European Commission, 2014). Correspondingly, in China the SLCP is essential to reduce soil erosion and increase forest cover by directly engaging over 32 million households for program implementation (State Forest Administration, 2003). The participating households received payments in the form of grain or cash for a maximum of 16 years for converting cropland on steep slopes to forest or grassland (The State Council, 2002; State Forest Administration, 2003).

The institutional arrangements of such governmental PES can vary, for example in terms of the area targeted, the payment mode, and the involvement of nature protection agencies. Thereby, certain institutions or combinations of institutions may be important for the success of the schemes (Meyer et al., 2015). Furthermore, as the final land-users and key stakeholders, have significant importance to the program implementation, the schemes need to interact with local institutional and socioeconomic conditions. Therefore, despite the leading role of government in policy design, the success of the program may be also determined by the fit of the governance arrangements with the local socioeconomic contexts (Vatn, 2010; Muradian and Rival, 2012). Reasons for performance of different PES has been broadly analyzed in terms of strengths, weaknesses, and limitations as well as issues of implementation (cf. Wunder et al., 2018; Reed et al., 2018; Salzman et al.,

2018; Hausknost et al., 2017; Chan et al., 2017; Wunder, 2015; Muradian et al., 2010; Vatn, 2010; Kosoy and Corbera, 2010; Fisher et al., 2009; Engel et al., 2008; Wunder et al., 2008). Lately, QCA has been used to determine preferred institutional PES arrangements and important socio-economic conditions for PES implementation, e.g. in our illustrative studies (Meyer et al., 2015; Chen et al., 2018). Thereby, both authors basically follow the 5 steps for QCA application that have been described in Section 2. Meyer et al. (2015) examine the governmental top-down design rules that make AEM successful in terms of environmental effectiveness, and Chen et al. (2018) determine the governmental institutions as well as other the existing socioeconomic conditions that are important for SLCP implementation at the household level. As results, both analyses attempt to determine one or more preferred institutional PES arrangements among several possibilities by drawing on QCA.

3.1. Step 1: Selection of the conditions

In the first step of QCA application it has to be clarified whether the institutional arrangements may be presented as set relations. Therefore, conditions that can present the arrangements have to be selected and conceptualized. The selection and conceptualization may be based on theory and empirical knowledge. Both studies derive assumptions on sets of key conditions relevant for program success based on PES, AEM, and SLCP literature as well as policy documents as the German CAP evaluations⁸ (cf. Sattler et al., 2013; Chen et al., 2015). In contrast to the literature based assumptions on the national level by Meyer et al. (2015), Chen et al. (2018) household level study is very much based on the local context, and they additionally interviewed local experts in the study area which solidified and confirmed the literature based pre-selected and defined assumptions. Meyer et al. (2015) basically assumed that certain AEM rules (QCA conditions) or combinations thereof may be potentially important for environmental effectiveness (literature on the relevance of certain conditions e.g.: Schader et al., 2014; Garrod, 2009; Ruto and Garrod, 2009; Matzdorf and Lorenz, 2010; Mettepenningen et al., 2013; Khanna and Ando, 2009; Prager and Freese, 2009). Institutional complexity reduction for condition specification occurred through focusing on general PES aspects and linking them to specific information on AEM. In conclusion, the authors finally determine five single conditions that are potentially relevant for environmental effectiveness: (i) focus on either one environmental goal or bundling goals, (ii) application to a certain area or habitat, (iii) technical, temporal, or area-wise application flexibility, (iv) implementation support of nature protection agencies, (v) access to AEM advice. Meyer et al. (2015) include 49 different AEMs from five German federal states in the analysis. In contrast, Chen et al. (2018) do not only focus on designed institutions but also consider other socio-economic aspects.

⁷ The CAP is a common policy for all the countries of the European Union. It is managed and funded at European level from the resources of the EU's budget. The CAP is financed through the European Agricultural Guarantee Fund (EAGF): direct support and market measures, European Agricultural Fund for Rural Development (EAFRD): rural development. National paying agencies, set up by each European Union country, manage the payments to beneficiaries (https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/cap-glance_en#legal-aspects).

⁸ The CAP is a common policy for all the countries of the European Union (see footnote 7). The CAP is regularly externally evaluated within the EU member states. As part of the CAP 2014–2020 the monitoring and evaluation framework helps to assess the performance of the CAP and its main instruments (https://ec.europa.eu/agriculture/evaluation/cap-monitoring-evaluation_en).

Table 5
Sufficient conditions for success of SLCP (adapted from Cheng et al., 2018: p. 17).¹

Term	Solution	Covered household number
1	INVO*MONI*FINA	18
2	INVO*MONI*PROP*OFF	6

Success = f(PART, PROP, OFF, MONI, FINA).

Frequency cutoff: 2.000000, consistency cutoff: 0.824345.

Solution coverage: 0.746718, solution consistency: 0.823329.

¹ The present of household involvement, property rights, off-farm labor allocation, effective monitoring, and financial incentive were labelled as “INVO”, “PROP”, “OFF”, “EFFE” and “FINA,” respectively.

Thus, they assume that certain institutional but also socio-economic conditions may influence rural households to reach the environmental goals of a governmental PES program: (i) household involvement, (ii) property rights, (iii) off-farm labor allocation, (iv) effective monitoring, and (v) sufficient financial incentive.

3.2. Step 2: Specification of the outcome

After a presentation of comparable institutional arrangements as sets and the definition of the conditions, in a second step, the output variable has to be specified. There are many different ways to specify the output variable. Meyer et al. (2015) and Chen et al. (2018) both are focusing the environmental impact of the PES, however, output definition and measurement followed very different ways. Meyer et al. (2015) specified the output variable “...success in terms of environmental effectiveness aspects...” by expert interviews. This took place according to fixed evaluation criteria based on the literature. The success of each AEM was determined based on a broader set of effectiveness aspects following an evaluation framework for public policies developed by Mickwitz (2003). Four determinants have been used to define success: “the relevance of the measure to cope with key environmental problems”, “the concrete impacts of the measure”, “the effectiveness in terms of impacts corresponding to the goals of the measure”, and “the variability of the measure to cope with changing external conditions”. The success evaluation was conducted by the evaluators of the Common Agricultural Policy in the German federal states. In contrast, Chen et al. (2018) evaluated the household implementation outcome by field observation. The authors measured the environmental outcomes from 128 plots of 59 SLCP-enrolled households by randomly placing a 100 m² quadrant. Within the quadrant they collected data on species diversity, species number, tree height and coverage based on the Braun-Blanquet cover-abundance scale (Braun-Blanquet, 1932).

3.3. Step 3: Transformation of data into crisp- or fuzzy-sets

In the third step the data has to be turned into crisp or fuzzy sets depending on the research question as well as the type and extend of the available data. Meyer et al. (2015) applied a csQCA for the AEM cases. Thus, the presence and absence of every single condition is determined dichotomously (1 or 0) for each of the 49 AEMs (see Table 1). The determination was undertaken by the staff of the agricultural and conservation administrations responsible for AEM programming. Meyer et al. (2015) choose csQCA based on their dichotomous information on the AEM rules as well as on the dichotomized data on success. Dichotomization has been carried out by considering AEM as successful only if it got the highest rating in terms of overall success. The success has been coded as (1 = successful and 0 = unsuccessful) as the AEM rules (present = 1 or absent = 0) (see Table 2).

In contrast Chen et al. (2018) employ fsQCA to determine the different pathways to success and failure among varied condition arrangements. The membership score is usually generated by calibration, and this crucial process should be transparent, open, and replicable

(Ragin, 2006). The fuzzy membership score of four conditions was a four-value scheme with “0”, “0.33”, “0.67”, and “1.0” indicating “fully out”, “more out than in”, “more in than out”, and “fully in”, respectively. Since household involvement is more complicated, the fuzzy membership scores of household involvement followed a six-value scheme, with “0”, “0.2”, “0.4”, “0.6”, “0.8” and “1.0” (see Table 3). Similarly, the fuzzy membership scores of outcomes were categorized with a four-value scheme to indicate “forest”, “sparse forest”, “developing forest or grass” and “re-farm”. Theoretical knowledge as well as empirical insights were used to generate the fuzzy membership scores of each condition using different measures. The selection of the measure followed the structural calibration procedure suggested by Basurto and Speer (Basurto and Speer, 2012). Each condition was explained by a measure, and each measure corresponds to a survey question.

3.4. Step 4: Analysis for necessary and sufficient conditions

In a next step, the analysis for necessary and sufficient conditions based on the truth table follows, generally by calculation software. In both studies fsQCA software is used.⁹ Meyer et al. (2015) find only one necessary condition, which then is considered to have limited significance due to its coverage value, whereas, Chen et al. (2018) found no necessary conditions. However, the sufficiency analyses show valuable results in both studies.

Meyer et al. (2015) identified three solution terms for sufficient conditions (see Table 4): The first two terms cover (Term 1) measures that target one environmental goal and a certain application area/habitat, are implemented with the involvement of the nature protection agencies and are supported with a reliable advice system; and (Term 2) measures that target one environmental goal and a certain area/habitat, provide flexible application possibilities, and are supported with a reliable advice system. The first term covers 15 cases (12 successful and 3 unsuccessful). The second term covers 13 cases (10 successful and 3 unsuccessful), and the terms overlap for 9 successful cases. Both terms generally support the authors’ assumptions. A third term (Term 3) covers measures that target one environmental goal with an opportunity for flexible application but no advice system; three successful cases are included without overlap with other terms. Because the term emphasizes the exclusion of an advice system, it challenges the authors’ assumptions in terms of the positive impacts of advice.

Chen et al. (2018) found two solution terms in terms of sufficient conditions for a successful outcome (see Table 5). The first term (Term 1) measures that a high level of household involvement, effective monitoring and attractive financial incentives can be sufficient for program implementation. The first term covers 18 cases (14 successful

⁹ There is different software for QCA application, e.g. fsQCA by Charles Ragin, Kriss Drass, and Sean Davey (<http://www.u.arizona.edu/~cragin/fsQCA/software.shtml>), TOSMANA developed by Lasse Cronquist (<https://www.tosmana.net/>) as well as QCA packages for the data analysis programs Strata and R.

households and 4 unsuccessful households). The second term (Term 2) shows that high levels of household involvement, effective monitoring, clear property rights, and off-farm labor allocation are also sufficient for program implementation. The second term covered 3 successful households and 3 unsuccessful households. Although all successful households in the second path overlapped with the first path, the second path is worth noting due to the presence of property rights and off-farm labor allocation.

3.5. Step 5: Examination of the inconsistencies and non-coverage

The verification of the QCA solutions for generalization requires an examination of the inconsistencies and non-coverage. Both, Meyer et al. (2015) as well as Chen et al. (2018) carried out such examination on a case base. Basically, differences and similarities in the contradictory cases are examined to detect vague or imprecise definitions as well as changes in meaning (cf. Schneider and Wagemann, 2012). Furthermore, expert knowledge has been considered. Regarding the cases that cause inconsistencies of Terms 1 and 2, Meyer et al. (2015) took for example certain statements of the CAP evaluators into account, indicating that some cases are almost successful, but conceptual or acceptance issues did not allow for a perfect rating. The authors interpret those cases as being “on the edge”. If these cases had been rated as completely successful, the consistency value would have increased. Those generally positive statements on the cases have been understood as general support of the sufficient conditions. In terms of the non-covered cases they detect that four of these six non-covered successful cases include one measure: payments to employ organic farming techniques. Thus, the authors argue that therefore a corresponding refinement of the assumptions may be indicated. Chen et al. (2018) face for example inconsistencies in terms of six unsuccessful households covered by their two terms. From the six households one head of household is the current village chief, and another is his brother. Further two heads of household are previous village chiefs, a fifth head of household is the Akhoond¹⁰ in the village mosque, and the sixth is a village elder. Due to the political and social role of these six households, they were special regarding program implementation, which can explain the inconsistencies.

3.6. Overall results

Both QCIA studies on PES could determine highly plausible solution terms, showing opportunities for successful governance structures in terms of environmental outcome. Both studies allow for generalization on the particular PES program design (AEM or SLCP) but also for PES design in general. They emphasize that the combination of certain conditions rather than a single condition alone is crucial for the PES success. Meyer et al. (2015) could furthermore illuminate aspects of PES integration into overall environmental policy, PES relation to property rights in natural resources, and output-based payments for well-defined ES. Chen et al. (2018) showed that governmental PES must be capable of adapting to different local conditions in a combinatory fashion. Even though csQCA can comprehensively present institutional arrangements in terms of dichotomous set relations, complexity has to be reduced to a certain degree. When compared to csQCA, fsQCA strengthens the QCIA by allowing the researcher to establish differences in degrees, theoretical knowledge, and in-depth empirical insights that were sometimes needed to understand the single cases and local content. However, the results are not as clear-cut and straightforward as in csQCA.

¹⁰ Also called Imam: An Islamic leadership position who may lead Islamic worship services, serve as community leader, and provide religious guidance.

4. Suitability of QCA for environmental governance CIA

The exemplary application of QCA to PES in Germany and China shows a general suitability of the method for CIAs of environmental and ecosystem services governance structures. In both of the exemplary studies, institutional arrangements as well as socio-economic conditions for successful PES could be determined. The findings display the results of reducing complexity of governance arrangements to make them comparable, test assumptions, develop new ideas, and derive policy advice. However, there are many critical issues and challenges that have to be taken into account when applying QCIA.

4.1. Complexity reduction and pitfalls in application

In particular, QCA provides a tool that can help to translate institutional complexity (e.g. many rules, many actors) into comparable arrangements. Thereby, on the one hand QCA application forces to, and, on the other hand it helps to concretize and reduce the many different aspects of governance structures to the most relevant ones. Such concretization and reduction is a part and a main concern of CIA to enable a comparison of different institutional arrangements (Monsees, 2008). Our example studies show that only a limited number of conditions in terms of institutions or socio-economic factors can be considered to make valid inferences – 5 in both cases (Chen et al., 2018; Meyer et al., 2015).

The process of such complexity reduction requires a forth and back in terms of theory, data collection, knowledge gaining, and concretization of the conditions. During QCA application the factors are generally discussed and changed within an intensive dialog with the cases (Rihoux and De Meur, 2009). Continuous comparison and re-integration of theory and case studies information as well as defining and redefining thresholds requires an in-depth case knowledge and iterative processes (Blatter et al., 2007; Rihoux and De Meur, 2009). Such in-depth case study knowledge and processes are part of many CIAs and therefore a QCA application suggests itself (e.g. Pahl-Wostl and Knieper, 2014; Brockhaus et al., 2017). The complexity reduction is supported by QCA's ability to clearly structure and summarize data and visually display clusters, patterns, and differences among governance structures within the truth table throughout the application process.

However, complexity reduction in terms of case, condition, and indicator selection has a strong impact on the research results and therefore, they must be based on a careful consideration to avoid subjectivity (Sehring et al., 2013). Referring to this, also Pahl-Wostl and Knieper (2014) underline that QCA is no trivial and results may be strongly influenced by the rules for e.g. fuzzy-set membership values or by the interpretation of consistency measures. They agree to Schneider and Wagemann (2012) who state that the popularity of QCA seems not to have kept pace with efforts to adopt standards of good practice in method application and documentation and encourage sharing of experiences in a wider community of practice.

Especially output variable determination, concretization, and measurement for environmental and ecosystem services governance approaches may be challenging. Comparison and assessment criteria in terms of type and quality (see Monsees, 2008) with data available and/or accessible are often difficult to design. Both case studies (Chen et al., 2018; Meyer et al., 2015) used very different approaches (an expert survey based on an evaluation framework and field visits with an ecologic mapping method) which worked out within the respective studies but both approaches also involve challenges and limitations. Future efforts on integrated evaluation methods on the success of environmental and ecosystem services governance approaches are highly recommended.

Serious critics also appear regarding csQCA and the required binary coding as it reduces complexity too much and many social and political phenomena cannot be adequately depicted as they are not binary presentable (Sehring et al., 2013; Schneider and Wagemann, 2012). Fuzzy-

sets may express the institutional arrangements in a more encompassing way. For example, in the SLCP case, participation and property could hardly be measured by an explicit number. Thus, generally we agree to Schneider and Wagemann (2012) and see that working with crisp-sets does create some issues. However, for a CIA of ecosystem services governance arrangements we argue that the applicability of crisp-sets may very much depend on the particular institutional and socio-economic governance context. Some aspects can be well reduced to binary expressions as for example the presence or absence of certain formal rules in the AEM example (Meyer et al. 2015). Accordingly, the question if csQCA could be used for CIA depends on the research question and available data.

Even if complexity in terms of condition numbers has been reduced QCA studies are always challenged by limited empirical diversity. For example, in both presented studies, the 5 conditions mean 32 possible combinations of conditions (Chen et al., 2018; Meyer et al., 2015). Ideally, all possible combinations can be observed and analyzed. However, this is hardly ever the case, and thus, for some combinations of factors the truth table will not show any cases. In the SLCP case, the truth table shows only 24 combinations. Thus, usually a number of the combinations are logically possible but do not occur in the real world (called logical remainders). There are different strategies to cope with this issue, basically to make certain assumptions on the logical remainders or not (see Schneider and Wagemann, 2012: pp. 152), but they all are not completely convincing. However, the problem has been assumed less relevant in terms of statements on the observed cases and more relevant for generalization (Sehring et al., 2013). This means for QCA that the researcher has to keep in mind for which purpose the QCA is carried out and which assumptions on logical remainders could be made. For making assumptions on logical remainders deep knowledge on the institutional governance arrangements and contexts is needed.

In sum, the disadvantages of QCA in terms of reduced case numbers, limited causal conditions, subjective condition selection and imperfect calibration (Basurto and Speer, 2012) should not be neglected. However, if applied carefully QCA provides a good tool for CIA in terms of cross-case comparison and complexity reduction.

4.2. Assumption testing and idea development

Generally, QCA may offer advantages over conventional qualitative and quantitative techniques in specific contexts. Many institutional or institutional economics issues are related to complex social-economic-ecological contexts which could hardly be targeted by statistical methods as regression analysis, as for example causal configurations (see Pahl-Wostl and Knieper, 2014). However, a qualitative case study approach does not allow for generalization (Sehring et al., 2013). QCA goes beyond statistical regression analyses and makes systematic comparisons while taking still into account the single case. It enables to understand if combinations of relevant institutional factors will lead to an outcome, different combinations of institutional factors can produce the same outcome, and if a condition can have different impacts on the outcome depending on its combination with other institutional factors and the context. Correspondingly, different institutional or institutional economist assumptions may be well targeted.

Thereby, in addition to institutions, also societal perspectives as values, interests, knowledge-claims, and combination thereof may be included into the analysis as determining conditions for success or failure of governance approaches (shown by Chen et al., 2018). Chen et al. (2018) combined institutions of the program as household involvement and monitoring with socio-economic context factors as off-farm labor. Thereby, the notion of multiple causation (more conditions can lead to the same outcome), is not generally opposed to the idea of identifying preferred institutional arrangements. It meets the perception that depending on the context, different institutional arrangements can be relevant, or else, different institutional arrangements can be

trade-offs regarding the same outcome. The results from both presented studies on AEMs and SLCP prove the importance of different arrangements as well as combinations of certain conditions to the success of governmental PES. QCA also allows researchers to better understand such complex causal relationships among a larger number of cases because both qualitative and quantitative data can be used.

Besides testing theories and assumptions, QCA can be used to falsify existing theories and develop new hypotheses. For example, if a large number of contradictory cases in a truth table shows that empirical cases have not been adequately assessed or that an important factor has been forgotten (Rihoux, 2007). High non-coverage also shows a missing element to formulate the solution. In the AEM example, the solution term with the highest coverage value explains 16 of 22 AEM. Thus, six AEM that are rated successful are not explained by any of the solutions, meaning that they do not comply with any successful condition. Four of these six relevant cases include organic farming. Thus, it could be assumed that organic farming could provide a sufficient condition for success (e.g., Meyer et al. 2015). Correspondingly, QCA may help to develop new assumptions and hypothesis on relevant institutional arrangements. This may be especially relevant in the course of research on ecosystem services governance advancement and a better integration of relations and feedbacks between humans and the natural environment based on the ecosystem services concept.

In sum, QCA offers different valuable opportunities for CIA in terms of hypothesis and assumption testing and development. Due to certain challenges and limitations explained in section 4.1, a combination of QCA with other qualitative and statistical approaches to confront the result or combine them (Sehring et al., 2013; Rihoux, 2007) may be valuable in terms of CIA (Pahl-Wostl and Knieper, 2014; Pahl-Wostl et al., 2012).

4.3. Inferences on policy design

Overall, we acknowledge a relevance of QCA as a decent way to determine preferred environmental and ecosystem services governance structures and provide input for the policy arena. QCA offers opportunities to analyze existing governance approaches and support implementation, monitoring, and evaluation as well as opportunities to provide innovative ideas for governance development. This applies not only in terms of an administrators' point of view and an optimization of the administrative decision-making but also for market, civil society, and cooperative governance aspects. As our results show, QCA may deliver guiding principles for designing certain environmental and ecosystem services governance approaches, it may provide insights into the social-economic-ecological factors that could be relevant for implementation, it could help on a further development of existing approaches, and it could give input for governance innovation. However, QCA encounters different challenges and limitations, especially in terms of complexity reduction, which have to be always taken into account before drawing back on certain results for decision making. Therefore, a combination of QCA with other methods can be a helpful. In any case, QCA may illustrate trends and help to detect problematic policy issues.

5. Conclusions

The objective of the paper was to show that the QCA approach and technique may be an excellent way to support CIA in terms of a formalized determination of preferred institutional arrangements for environmental, or rather ecosystem services governance. Therefore, this work explains how QCA works, determines how it could be applied to CIA, and defines basic steps for QCA application. The application of crisp-set and fuzzy-set QCA to CIA are illustrated step by step based on two case studies in Germany and China, and challenges and opportunities of the applicability of QCA to CIA are discussed. The paper firmly explicates that QCA may generally support CIA very well. In particular,

the technique helps to structure the complexity of the included units which is part of many institutional economic and institutional approaches. The method provides an opportunity to formalize the qualitative comparative aspects that are often part of CIAs and also allows for the integration of qualitative and quantitative data. Furthermore, contrary to other methods, especially quantitative approaches, the QCA method shows combinations of conditions that are relevant for a certain output and does not focus on the impacts of single conditions. Finally, the decently verified and interpreted results provide relevant policy implications that can be communicated to the relevant decision-making bodies and decision makers. However, generating reliable and utilizable QCA results could be very time-consuming in terms of data gathering, processing, and interpretation and requires the corresponding resources.

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Discussion Piece

Strengths and weaknesses of the Net-Map tool for participatory social network analysis in resource management: Experience from case studies conducted on four continents

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Abstract

For researchers, conducting face-to-face interviews is always a challenge as it often turns into a one-way directed information retrieval. Therefore, interviewees not always are very motivated, enthusiastic and cooperative in responding to the questions. In the end, this has implications for the quality of the interview data. To improve the interview setting and the resulting data, in several projects the Net-Map tool was used to conduct participatory social network analysis. The tool is a combination of in-depth interviews and participatory network mapping. During the interviews, the interviewee draws the network of relevant actors, notes down their motivations and evaluates and displays the actors' influence and benefits by building towers using any kind of stacks. In this research note, we present the strengths and weaknesses of the method against the experiences with applying the Net-Map tool on four different continents and give ideas for improvements and further research.

Keywords

Participatory research, social network analysis, governance, community-based conservation, natural resource management

Background

Net-Map is a participatory, innovative tool for social network analysis (SNA), which combines elements of qualitative and quantitative research. During an in-depth interview, the interviewees (individuals and groups) create and draw maps of the networks they participate in. While drawing the network, they engage in a process that helps them to understand and clarify their own view of the given situation, discuss the situation and finally develop a strategic approach to improve their own networking activities. The advantages and disadvantages of Net-Map compared to classical SNA are more implicitly discussed in the literature (Campbell et al., 2014: 431; Hauck et al., 2015; Schiffer and Hauck, 2010). In classical SNA, the analysis focuses primarily on data raised in a quantitative manner, which makes it difficult to understand the underlying reasons for complex and dynamic structures, and there are typically time gaps between data collection and results (Reed et al., 2009). In contrast, the Net-Map approach additionally

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Table 1. Comparison of different collaborative governance approaches in Costa Rica, Germany, Tanzania and China.

	Costa Rica	Germany	Tanzania	China
Project type	Community Blue Carbon Project	Backwater Advisory board 'Staubeirat', Citizen Foundation 'Kulturlandschaft Spreewald'	Upgrading strategy Tide Ridges	Sloping Land Programme
Governance type	Community and Market, a bit of State	State and Community	Community + Science	State Hierarchy, Community takes over
Top-down/bottom-up	Bottom-up	Top-down (Backwater Advisory board); bottom-up (Citizen Foundation)	Bottom-up	Top-down
Important Intermediaries	Non-governmental organization	Water and Soil Association; Foundation	Researchers, group leaders	Villages Chiefs (not foreseen)

Source: Own elaboration.

supports qualitative information based on individual actors' viewpoints and perceptions, which helps to combine purely structure-oriented quantitative network analysis with more qualitative aspects such as narratives and participatory approaches (Hauck and Schiffer, 2012). In addition, in quantitative SNA, each actor reports his or her own ties to other actors, whereas in the Net-Map tool, the actors also report their perceptions of ties between third parties. Therefore, at least one representative of every actor group must be interviewed when using the Net-Map tool in individual interviews to prevent bias when aggregating single networks for further analysis of the overall network. In principle, it is also possible to use Net-Map in group interviews with all relevant actors and construct the overall network together. This, however, bears some additional challenges as the actors have to coincide about the network they draw. This is time-consuming, more difficult to control biases and challenging, in particular in conflictive networks.

Based on experiences with applying this research tool in four different countries and continents, we document the strengths and weaknesses of the proposed method against the international background and propose ideas for improvements and further research.

Case selection and method

The tool was used to analyse the governance models in four different research projects. A governance model is a special arrangement of institutional structures and actor constellations of which three ideal types are distinguished: hierarchies, markets and community management based on cooperation (Vatn, 2010: 1246). Although they focused on different topics, all of the types we present in this article analyse collaborative governance approaches in environmental management. Collaborative governance approaches seek tailored solutions for complex problems and are characterized by the incorporation of all concerned actors and their specific needs, by using all kind of resources (e.g. local knowledge), by using social capital and by being flexible and adaptive (Mert and Pattberg, 2015).

In Costa Rica, a community-based payment scheme for ecosystem services was investigated in which fishermen are paid for restoring mangroves and are also active in educational work. In Germany, collaborative governance approaches were analysed in which actors from public, private and civil society worked together for water management and biodiversity protection. In Tanzania, the functionality of farmer groups implementing so-called upgrading strategies, such as tide ridges within a village that aim to improve food security, were assessed. In China, a state-financed payment for ecosystem services scheme was studied in which peasants are paid for reforesting part of their land (see Table 1).

Most interviews were conducted with actors at the local level. For each study, the following comparable information was gathered: determining the important actors in the governance approach, their connections with each other, their motivations to participate and their influence on and benefits from the schemes.

The Net-Map tool which is an empirical research tool developed by Eva Schiffer and the International Food and Policy Institute (IFRPI) was used for data collection. Net-Map is used

to (1) visualize implicit knowledge and understand the interplay of complex formal and informal networks, power relations, and actors' goals; (2) uncover sources of conflicts as well as potentials for cooperation; (3) facilitate knowledge exchange and learning processes; and (4) develop visions and strategies to achieve common goals. (Schiffer and Hauck, 2010)

To specify the context for which the network is mapped, an overarching Net-Map question is first formulated: 'Who has influenced/can influence XY where and when?'

The interviews include four steps:

1. Recording the participating or influencing actors. During this step, interviewees identify the actors within the network, write the names on actor cards and distribute them on a large sheet of paper. To gather additional information, they are asked what makes each actor important.

2. During the second step, different links between the actors are identified. The interviewer asks for one specific link between actor A and all other actors, followed by the same link between actor B and all the other actors, and so forth, and then draws arrows connecting the actors. When one link is finished, the next link is mapped with a different colour. In the reviewed studies, we asked for different relationships between the actors such as personal contacts, trust, flow of money or materials, written contracts and exchange of knowledge; the arrows are all displayed in different colours.
3. During the third step, the motivation of each actor is established, a legend is drawn and symbols are placed beside each actor's card. In some cases, the interviewee was presented a list of five pre-defined motivations based on the case study experience which were identified through qualitative interviews beforehand; these include economic, ecological, social, image-related and knowledge-related motivations. Additional information is gathered by asking for the reasons behind specific motivations.
4. Finally, the interviewee is asked to indicate how strongly each actor is influencing the result in the overarching Net-Map question. He or she arranges towers (which are built of some stackable material such as small bricks and chocolate) for each actor according to the estimated importance. The greater the influence of the actor, the higher the tower. Towers of different actors can be of the same height, and the heights of towers may or may not be restricted. The interviewer notes the height of the towers onto the map and gathers additional information by asking for reasons for the actors' influence.

This visualization process is accompanied by narratives which the interview partners provide to explain the drawings.

In our studies, the Net-Map tool was used to analyse five main aspects: (1) Who are the important actors in a network? (2) What are the relationships between those actors (such as flows of knowledge, information, money and other resources, contracts, reporting, trust or conflicts)? (3) What are individual actors' motivations or goals (e.g. ecological, economic, social, image, knowledge, love, joy)? (4) What is each actor's, influence or importance?

To adapt the tool (Schiffer and Hauck, 2010) to our research needs for the case of Costa Rica, Germany and Tanzania, the forth step was repeated, asking not only for actors' influence and importance but also for actors' personal benefits, income food availability, learning and trust.

In each case study, individual interviews were conducted by the lead researchers of the respective project. Local staff only served as translators in the case of Tanzania, but they were trained in the interview method and the terminology was defined in their presence. An overview of the different interview conditions is presented in Table 2.

Research results

After data collection in each study was finalized, we conducted a short survey with open questions among six researchers that had been involved with the studies. They were asked for their opinions regarding the strengths and weaknesses of the Net-Map tool in relation to (1) interactions with interviewees, (2) collection of scientific data, (3) structural aspects of the tool (e.g. guidelines, interview steps and duration) and (4) what they would change to improve the method.

Challenges regarding the interaction between the interviewee and interviewer can be attributed to either methodological challenges or differences in the respective research design or country context of the studies.

Methodological challenges

In Costa Rica, it was sometimes difficult to keep the interviewees focused and not make them deter from the topic, whereas in Germany, the experience was mixed. Some interviewees perceived interviews as time-consuming and annoying, but others felt that interviews were more interactive and interesting than conventional interview techniques.

Challenges to data collection were, in Germany, related to actors who performed different roles in the network. This made it difficult to unmistakably assign roles to one particular actor as their roles were associated with several actors, and thus it was more difficult to assess their relationships. In addition, the individual interpretation of terms used during the interviews deviated, which made it difficult to secure common understanding. In Tanzania, the main challenge was to process the acquired data because of a large number of interviews. Although this took more time and the data-acquisition schedule was very dense, the data richness allowed not only for an elaborated case study comparison design of different networks across different villages and regions but also for a broader statistical analysis beyond network measures (e.g. a chi-square test for motivations and influence towers). In China, only a small number of actors was part of the governance approach and interviewed, so the data quality was highly dependent on the interviewer's ability to obtain the most information possible and to subsequently interpret the Net-Maps. In Costa Rica, data collection was not a challenge, because people are more relaxed and easily communicate their perceptions.

Challenges associated with specific case study conditions

In Tanzania, there were challenges related to the illiterateness of interviewees, which was solved using icons for actors. In the beginning, the participants felt as though they were at a school and first had to become comfortable with the situation to provide their answers. It was sometimes difficult for them to make statements regarding other persons. As such, it was necessary to take care to not make them feel

Table 2. Comparison of different interview situations in Costa Rica, Germany, Tanzania and China.

	Costa Rica	Germany	Tanzania	China
Number of interviews	11	18	177	34
Number of interviewers/interview	2	1	1	1
Interview language	Spanish, English	German	English (with Swahili translation)	Chinese
Use of interpreter	No	No	Yes	No
Places where interviews were conducted	Open space in front of interviewees home, inside interviewees home, class/workshop room in field station, office meeting room	Home or office place of the interviewees (open and closed spaces)	Open space or closed space, home of the interviewees, community house and offices	Offices of government officials, farmers home or open space close by
Length of the interview	1–2.5 hours	1–2.5 hours	1.5–3 hours	10 minutes–1 hours
Individual interviews or focus groups	Individual	Individual	Individual	Individual
Number of interviewees per interview	1–4	1	1	1
Interview partners	Local community/fishermen, NGO members, business	Local and regional administration, associations, farmers, Civic Local community/fishermen/farmers	Local community/farmers, extension staff, NGOs, government officials, villages chiefs	Government officials, village chiefs, local community/farmers/households
Educational background of interview partners	From very basic to university level	From very basic to university level	From very basic to university level	From very basic to university level
Regional coverage/scale	National and Local	Regional	Local	National, regional and local

Source: Own data.

NGO: non-governmental organization.

ashamed when they did not know an answer, and to give them sufficient time to think and therefore maintain their confidence. The length of the interview was usually long, up to 3 hours, which caused weariness and challenged their ability to concentrate on the topic. Similarly, in China, it was difficult for the interviewees to make statements regarding the involvement, links or influence of other actors. Interviewees could comment on their own level (e.g. other farmers in the village), but not on government employees on the regional or state level. This finding revealed the opacity of the network. Local actors had a limited perspective on the network up to hierarchical structures. Although they were experts and an active part of the network, they only knew about the local structures.

Regarding structural aspects, the main challenge was the length of the interview. In Germany, Tanzania and Costa Rica, the interviews were often considered to be too long, which made it difficult for people to stay focused on the topic at hand, such as staying focused and concentrated or thinking about other urgent tasks they must do. In China, the interviews were considered to be too short. People especially at the local level had less knowledge and could not comment on higher levels, so the interpretation of maps and the resulting

situation was difficult for the interviewer because network narratives did not offer much additional information.

Advantages of the Net-Map method that were mentioned in all four case studies were that the method is easy to understand, very intuitive and contains an element of fun. In addition, the step-by-step procedure is simple and subsequently adds complexity to the network while explanatory information is collected during the qualitative part of the interview. Because the stakeholders construct their network on their own during the interview, they address the actors very consciously. This creative act results in being very helpful for reflecting their relationships. The prompt visibility of the collected information makes interpretation possible immediately, as well as makes discussion of the results easier. Most importantly, both the interviewer and interviewee learn during the process, and knowledge exchange occurs in both direction. This makes the tool suitable for interviewing not only single persons but also groups of people. As the data become structured, comparison between interviews becomes easy. In addition, the combination of collecting qualitative and quantitative data is an added value of the method, as it presents a complete picture and allows mixed-method analysis.

Discussion and conclusion

Although our findings do not allow for a systematic case study comparison due to the slightly different research design of each study, we found that Net-Map is a very flexible tool that is suitable for three out of the four different socio-cultural contexts. Only in China the tool showed limited suitability because of its hierarchical context. This coincides with the findings of Reed (2008) that 'methods should be selected and tailored to the decision-making context, considering the objectives, type of participants and appropriate level of engagement' (p. 2424).

The tool addresses several problems that may occur during conventional interviews, such as reaching transparency and common understanding through visualizing the situation, overcoming shyness or the will to talk and creating a comfortable atmosphere that keeps the participants involved, which in the end improves not only social learning but also the quality of the interview data (Campbell et al., 2014; Schiffer and Waale, 2008).

Although the use of the tool is time-consuming, it has the great advantage of enhancing learning effects. These learning effects occur immediately when the interviewee is reflecting on his or her perception of the network. Immediate data analysis and discussion is possible, in contrast to classical SNA and other participatory methods for governance analysis such as experiments or multi-criteria analysis. Similar to participatory modelling, the resulting map is a product which can serve as a boundary object, which acts as a device 'for the development of a shared language to address different objectives and integrate different forms of knowledge' (Hauck et al., 2015: 408). The maps can be discussed in a focus group with all interviewees to reach a common understanding of the overall network perception, which would be a second step of social learning.

On one hand, the maps help to make tacit or implicit knowledge, or the 'know how' (Roberts, 2000: 431), visible. The interviewees report their perception of the network, and only the overlay of all interview data depicts the entire network picture. As actor groups can be split into interviews or focus groups, the method gives the less powerful a chance to explain their perception of the network but makes the situation difficult if different actors discuss their perception at the same time. On the other hand, when there are diverse actors with different educational and knowledge levels, the immediate mapping of the lack of knowledge or shyness to utter perceptions becomes obvious during the interview. In this case, the learning effect occurs in the end when the resulting map is discussed with the interviewees.

The visualization of the results for participants was used as a motivation to take action because it enhances the understanding of the network and roles of individuals/groups that must be improved in order to achieve a better performance. For example, after the interviews, the participants realized the weaknesses of their network and tried to do 'something

about it' for improving the situation; for example, if the group leader is not fulfilling his or her role in the group, members would have a meeting to try to fix it.

However, for conducting Net-Map interviews, researchers must consider the specific settings in the case study they want to investigate, especially regarding power relations and the distribution of knowledge. The method seems to function well in open societies where uttering critiques, thinking out loud, speculating about and for others, and abstract thinking is common. Literacy helps, but the method can also be applied to involve illiterate people because of the visualization motivations and actors' names can be represented by icons. In general, the method seems to be intuitive enough to work for everyone, independent of the educational or social background of the interviewee. Knowledge differences of the distinct actor groups are perceived to be mainly due to lack of information, not to educational standards. Altogether, it seems important to use the method in a flexible way and to adjust it to the given situation so that interviewees can familiarize themselves with the method and continue at their own pace. However, in contexts with strong hierarchies, the method seems less suitable because hierarchies are the more accepted social structure compared to networks. Local actors are not familiar with answering open questions and do not have enough information due to poor participation in the design of the governance models. Only people with hierarchical power are capable of sharing such information. In addition, in this context, it was difficult to make people comment on other involved actors, as well as on the links and influence within social spheres other than their own. Actors are not really interested in clearly addressing power structures and dependent actors do not feel free to evaluate other actors in their network.

Moreover, in all case studies, the level of education differed and influenced the application of the tool. Despite conducting pilot interviews to test the wording of the questions, it was sometimes difficult to use the same terms for every actor group, such as in the German case study. This may be a limitation of the method, as it is hardly possible to use the same language if the actor heterogeneity is very high. In contrast, the strengths of the tool are the visualization possibilities, which allowed including, for example, illiterate participants in Tanzania.

The different education levels are linked to the wider profile of the different actors, which had influence on the behaviour of the interviews in all case studies. Whereas grassroots stakeholders generally had more time but were less keen on discussions, academic or business stakeholders had time constraints but were more open to discussions.

Finally, the interview questions must always be framed in the local political context. In some cases, such as in China or Germany, the questions broached more sensitive topics than in Costa Rica or Tanzania, which influenced interviewees' behaviours. The experience also showed that if the interviews are short on time and information, a lot of local

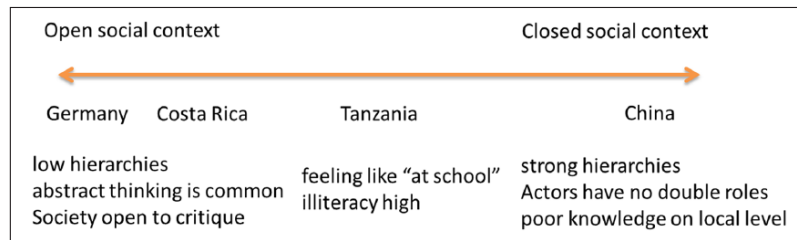


Figure 1. Continuum of social context based on power and knowledge.

knowledge is required from the interviewer to be able to interpret the maps. Therefore, we recommend good preparation and prior training of the interviewer, as well as proper pre-testing of the research questions and wording in the original context. Using an interpreter for local languages such as in Tanzania did not make a difference in the utility of the method because the interpreters were trained in the interview method beforehand. We did not find the method to be very suitable for highly hierarchical settings. For this reason, we encourage more research regarding power relationships and knowledge hierarchies in different social and institutional settings when applying the Net-Map tool (Figure 1).

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5 Synthesis and Discussion

5.1 Overall results

The first paper provides the conceptual basis for all subsequent studies presented in this dissertation, as it is an overview of the effectiveness and institutional challenges of China's SLCP. The second paper explores how socioeconomic and institutional conditions encourage rural households to reach the primary environmental goals of SLCP. The third paper shows how local dynamics derived and shaped the SLCP's implementation. The fourth paper illustrates and discusses the method used in paper 2, comparing it with another case study in Germany. Finally, the fifth paper presents the strengths and weaknesses of the method used in paper 3 based on the experiences of four different countries. The results of the five individual papers and corresponding research questions for the dissertation are briefly summarized in Table 1.

	Research question	Result
A 1	What are the institutional challenges for the effectiveness of SLCP?	Hierarchical (top-down) approach Household participation Administrative coordination Poor monitoring Compromise of a multi-goal approach Flexible payments Property right
	What are the institutional and socioeconomic conditions of the implementation of SLCP at household level?	Household involvement Financial incentives Off-farm labor allocation Property rights Effective monitoring
A 2	What are necessary and sufficient institutional and socioeconomic conditions for a successful SLCP implementation at the	Path 1: the combination of household involvement, effective monitoring and financial incentives Path 2: the combination of household involvement, effective monitoring, clear property rights and off-farm labor allocation.

	household level?	
	What are necessary and sufficient institutional and socioeconomic conditions for a failed SLCP implementation at the household level?	Path 1: the combination of household non-involvement and on-farm labor allocation Path 2: the combination of poor property rights and household non-involvement Path 3: the combination of financial incentive, weak monitoring and poor property rights
A 3	Which roles do the local agencies and household play in shifting a compensation program to a governmental PES?	Local agencies, including village council (farmer councils), village chief and forest station may be forced to coordinate and ideally deliberate the terms and conditions of implementation and management options. If the negotiations between local actors can be improved and their role as intermediaries can be promoted, the environmental goals may be achieved in combination with greater self-interest.
B 1	How to apply QCA approach to support Comparative Institutional Analysis to determine preferred institutional arrangements among several possibilities?	Step 1: Selection of the conditions Step 2: Specification of the outcome Step 3: Transformation of data into crisp- or fuzzy-sets Step 4: Analysis for necessary and sufficient conditions Step 5: Examination of the inconsistencies and non-coverage
B 2	What are the strengths and weaknesses of using the Net-Map tool for participatory social network analysis in ecosystem service governance?	Strengths: 1) improving the quality of the interview data 2) Enhancing learning effects 3) Making tacit or implicit knowledge 4) Visualization for taking action 5) Intuitive to work for everyone Weaknesses: 1) Time-consuming 2) Might have problem with strong hierarchies 3) Local knowledge is required from interviewer

Table 1: Short summary of the result of publications

5.2 How to improve the design of governmental PES

This dissertation has shown that governmental PES, like SLCP, could create significant economies of scale and environmental effectiveness under certain institutional conditions. However, the actual implementation of SLCP has deviated substantially from the market approach promoted by the central government, as well as from suggestions by domestic and international researchers. While the design of the program is often framed as a PES mechanism, its implementation could be actually viewed as a compensation for legal restriction. A significant gap between vision and implementation has been observed in terms of governance and effectiveness (Table 2). As the PES in China is strongly grounded in a specific institution, the improvement of government PES should be featured along with the causes of the gap, rather than simply embracing PES elements from theory. In order to do so, Paper 1 proposes that the program's effectiveness is a result of interacting driving forces, whereas institutional factors play a key role in shaping the outcome. Paper 2 suggests that the effectiveness of the SLCP can be improved if key relationships are jointly understood and addressed. Paper 3 argues that local dynamics drive and shape the program implementation, and that particular attention should be paid to the interaction of local actors.

	Design	Implementation
The Coasean type/Pure market-based PES		
The voluntary principle (Wunder, 2005)	√	?
Clear defined ES (Wunder, 2005)	×	×
Market based exchange (Wunder, 2005)	×	×
Conditionality (Wunder, 2005)	√	×
Additionality (Wunder, 2005)	×	×
Local acceptance (Corbera et al. 2009)	√	√
Output-based payment (Engel et al. 2008)	×	×
The Pigouvian type/governmental PES		
Incentive based exchange (Muradian et al., 2010)	√	√
Government intervention (Vatn, 2010)	√	√
Intermediaries (Muradian et al., 2010)	×	?
Social performance (Muradian et al. 2010) e.g. Poverty alleviation	√	√

Table 2: Comparison of SLCP in design and implementation with PES theory

The SLCP was viewed domestically as the flagship program for the transition from subsidy (bottom-right in Figure 6) to incentive-based governmental approach (bottom-left). However, this dissertation has indicated that the SLCP is the overlap of governmental-financed payments and compensation payments for legal restrictions (middle point of two bottom corners), according to the governance model developed by Matzdorf (Matzdorf et al. 2013). However, Eco-compensation can be considered more to right side of the model (Figure 6).

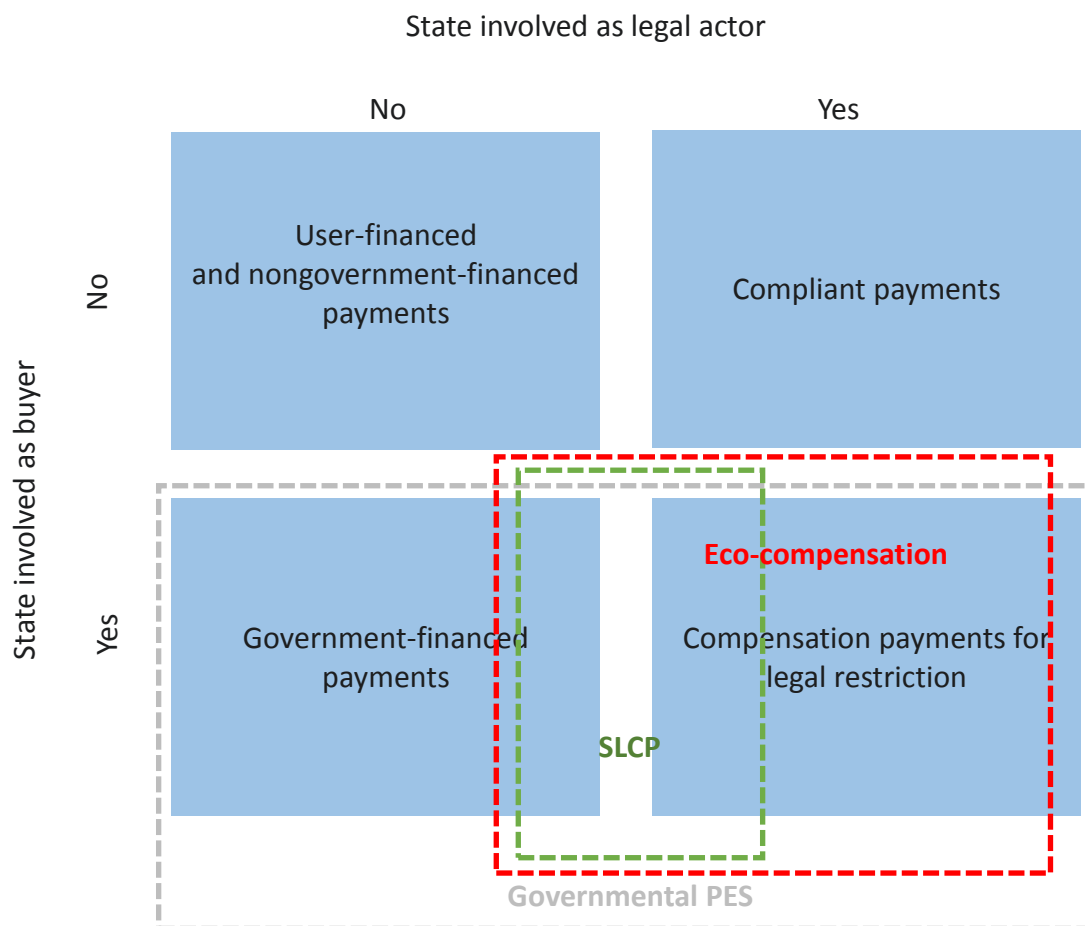


Figure 6: SLCP in the PES governance model (adapted from Matzdorf et al., 2013)

5.2.1 Implications for governmental PES in China

The gap between design and implementation is often viewed as an ‘implementation barrier’. SLCP is embedded in incomplete institutional settings and particular attention should be paid to the institutional setting. To answer questions A 1.1 and A 1.2, the relevant institutional design conditions for reaching PES environmental goals are reviewed in paper 1 and elaborated on by papers 2 and 3. The implementation

has been shaped by institutional and socioeconomic conditions, interacting broadly by a top-down policy.

The status of property rights in China is a very unique one. Paper 1 finds that property rights are generally thought to influence household behavior regarding resource use and environmental management. However, Paper 2 shows that there are increasing concerns surrounding uncertainty over the lack of property rights in rural China. Both the separation and limited duration have posed great challenges to “well-defined property rights”. However, as the property rights issue in China is embedded in the political system and ideology, it is less likely to see any dramatic changes in the near future. Therefore, PES in China has to adapt to this precondition and use other mechanisms to fix the vacuum in property rights. For example, Chinese governments have used a combination of regulatory and voluntary manoeuvres to encourage transactions. However, caution should be paid here, as this kind of “solving” incomplete property rights may come at the cost of undermining the willingness of households. While this approach may be effective in the short-term, the strength of property rights is still needed, especially for the far-off farm oriented households who have successfully grown the trees.

China is developing an alternative model of the role of non-governmental actors in environmental governance (Guttman et al. 2018). This dissertation found that the local government affiliated or related agencies could potentially fill the role of intermediaries in bringing together government and local households for up-front negotiations. In order to integrate the centrally designed approach specifically in to local social and ecological contexts, local institutional resources, including the involvement of local government agencies, village councils (farmer councils), village chiefs, forest field stations and farmers may be forced to coordinate and ideally deliberate the terms and conditions of implementation and management options. They are jointly responsible for collecting and reporting information about local economic and ecological conditions, communicating higher directives to individual households, allocating reforestation quotas, calculating payments, providing technical supports and monitoring project implementation. This collaboration between local actors and their motivations and interests for the implementation on the ground play crucial roles. The role of local agencies as the “in-system”

intermediaries for governmental PES should be recognized and appreciated by the government (Paper 3). However, as tasks and responsibilities are not well defined, overlaps and conflicts between local actors may cause substantial ineffectiveness in program implementation. Furthermore, bureaucratic complexity and rent-seeking behavior could undermine any cooperation. Rent-seeking behavior has been reflected in implementation, as local government agencies have found other ways to benefit from the system by increasing land conversion quotas, exceeding quotas and bargaining for more payment. As a result, local agencies view SLCP payments as opportunities for financing their operation's costs. Conflicts between local agencies and households were created when local agencies tried to minimize administrative costs by including parcels that were contiguous.

Attention should be paid to understanding the combined effect and the trade-off effect. Paper 2 addresses questions A 2.1 and A 2.2, indicating that the combination of certain conditions rather than a single condition alone is crucial for the success or failure of household implementation of SLCP. Paper 4 takes this one step further, comparing the combination of certain design rules for governmental PES in Germany and China. A number of studies have presented certain design features and synthesized some common conditions for PES (Sattler and Matzdorf 2013). However, most existing studies have considered the various conditions individually and independently. Notably, Meyer et al. (Meyer et al. 2015) first showed that combinations of certain design rules influenced the success of a governmental payment scheme in Germany. Similarly, our SLCP study (Paper 2) shows that the combined effect of certain conditions rather than single conditions should be considered. In particular, for a successful reforestation program, household involvement, effective monitoring and financial incentives should all be present. While reforestation requires continuous management with a reliable reward system, this combination can foster a positive feedback loop by building long-lasting cooperation between households and government. We therefore want to call attention to combination when designing a PES scheme.

5.2.2 Outlook of PES in China

The development of SLCP works in parallel with the domestic concept of eco-

compensation, which has laid the groundwork for PES in China. Eco-compensation has become a key initiative of the Chinese government and a hot topic in society. Besides this, it is indicative of a greater emphasis being placed on not only developing innovative market-based instruments, but also on resolving property rights and equity. As most eco-compensation projects in China have used public funds via top-down approaches, they have often been criticized for insufficient local engagement, poor administration, and corruption. While SLCP is fully funded by the central government, local governments in China have been important contributors to many centrally-initiated eco-compensation programmes (Figure 7), rapidly adapting central designs to suit their own needs. Recently, both central and local government have explicitly stated their aim of diversifying funding sources, suggesting that significant opportunities exist for private sectors being brought in as key partners and stakeholders. This is a good reason to believe that private actors may play more important roles in the near future. Some other structural changes, such as climate change, provide additional opportunities for re-structuring China's PES in a new direction. Therefore, future research should focus on how to fit a more market-based PES.

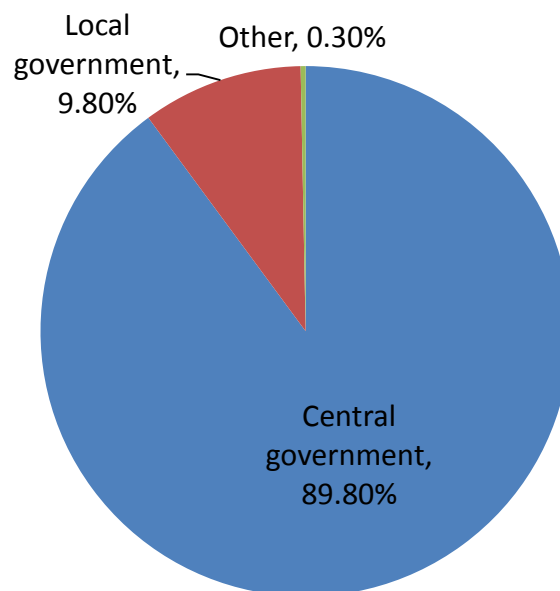


Figure 7: Non-government investment in Eco-compensation (Leshan et al. 2016)

Another trend of governmental PES in China is shown in the link between eco-compensation and poverty alleviation. Poverty alleviation is the second goal of SLCP,

after forest restoration. However, the dual goals of ecological conservation and alleviation of poverty have placed local government in a dilemma, weakening its ability to ensure program compliance. Punishing poor performance tends to worsen living conditions in poor households. In 2014, the central Chinese government initiated a campaign of “Targeted Poverty Alleviation”. As poverty relief has been put at the top of the political agenda, eco-compensation became part of this critical national strategy. As a result, SLCP and eco-compensation have acquired more meaning when alleviating poverty than for their ecological objectives. This replacement may make the program look more like a subsidy program than a PES program, which might be a serious setback for transforming the traditional approach. Recently, eco-compensation has had a new focus for cross-sector and cross-boundary cooperation. China’s ecological conservation domain has been divided into different sectors, such as farmland, grassland, forestry and water conservation. Governmental departments in these sectors are separately responsible in their own sectors, and cross-sector cooperation was very challenging. Furthermore, how to balance the benefits between different regions was another difficult task. For example, west parts of China, which had played a key role in ES provision, often had conflicts with the east parts when not paying enough for ES. How to cope with the existing institutional settings and break down the barriers between different sectors and regions is, until now, not clear.

In late 2016, the central government decided not to extend the contract for land that came first (1999-2005) (State Forest Administration 2016), despite calls for extensions by provincial governments and the scientific community. According to the State Forest Administration, from 2017 onward, the successfully-established “ecological forest” could be categorized as a national public forest, which is entitled to annual compensation. The successfully-established “economic forest” was to be developed with the under-forest economy (agroforestry), and even allowed to be cut down if permitted by a local authority (State Forest Administration 2016). The final decision made by SLCP did not offer a solution to those who failed to achieve this outcome. Therefore, timely policies should be made for these “ignored” households by guiding them from previously failed paths on to successful paths. In particular, the combined effect of household involvement and governmental monitoring can help

households break down socioeconomic and institutional constraints.

5.2.3 Reflection on global PES debates

On a global level, debate surrounding the private Coasean PES schemes vs. public Pigouvian schemes (market-based approach vs. hierarchy-based approach) is a prime consideration in PES research (Muradian and Rival 2012, Vatn 2015, Wunder 2015, Raes et al. 2016). Market-based PES for environmental governance has been promoted as being among the best-suited instruments for delivering equitable ES (Wunder 2013). As the well-known advocate of market-based PES, Wunder (Wunder 2013) admitted that “PES do require a payment culture and good organization from service users, a trustful negotiation climate, and well-defined land- or resource-tenure regimes for providers”. With such preconditions, PES might be promising in some cases. However, its potential could be limited in others. Against this backdrop, literature increasingly emphasizes that PES are not ‘real’ markets, but rather hybrids that lie between markets and hierarchies (Muradian et al. 2010).

The Chinese experience has shown that governmental PES has great potential for creating significant economies of scale and cost efficiencies when compared to other types of PES (Engel, Pagiola et al. 2008). In China, vast administrative resources, together with tremendous investment, have enabled large-scale payment programs to be implemented, with broad geographic cover and strong participation. The SLCP can be an important milestone in governmental PES in China and other countries with similar institutional settings. If the problem of property rights and intermediaries is an established feature of the political and social context, many developing countries might benefit from the Chinese experience.

Notably, incomplete institutional settings didn't prevent SLCP's wide acceptance and fast development at the beginning phases of the program. In these phases, farmers' interests (saving time from on-farm work to off-farm work) overlap with SLCP's goal of land retirement. Farmers are willing to retire some low-productivity lands in exchange for government payments in order to free themselves from time-consuming farm work. Therefore, farmers, village councils and local officials share some common interests (He and Sikor 2015). As local government affiliated or related agencies could potentially fill the role of intermediaries, the Chinese

governmental PES tend to have a great advantages in mobilizing rural households for enrollment. SLCP had attracted many participants in the beginning phases and was praised as an efficient approach to solving urgent environmental problems in the short-term. However, it would be very difficult for government affiliated or related agencies to overcome bureaucratic complexity and rent-seeking behavior. After enrollment, some of the missing principles appear to be very important in keeping households from simply making one-off acts and to continuing them, with long-lasting effort being made. The program's predominantly top-down approach and lack of true voluntariness, conditionality, property rights, differentiation and mechanisms for ensuring sustainability are understood to be critical factors in explaining possible failures in the long-term. Therefore, there is no bypass for reaching long term success in terms of environmental effectiveness, in the absence of key PES elements (real incentives).

The lessons learnt from China can be viewed through the lens of transaction cost theory (Williamson 1979, 1996). In China, the majority of rural households are very small-scale and their land property rights are not clearly defined. As the costs of bringing parties together can be enormous, therefore, the argument exists that administrative authorities with institutional resources are necessary for engaging in transactions. This could substantially reduce transaction costs, bringing together millions of ES sellers and negotiating and implementing contracts (Kolinjivadi and Sunderland 2012). However, government control of transactions is unlikely to reduce the total transaction cost for PES. The ambiguity found in property rights and the dual role of the government as intermediary and 'buyer' may cause bureaucratic inefficiency, rent-seeking behavior and cheating, signaling higher internal transaction costs (Kolinjivadi and Sunderland 2012). Compared to wholly voluntary PES, the total transaction of governmental PES could be even higher in the long-term, unless collective decision-making at local levels can be promoted.

Eco-compensation and PES are good examples of Chinese policy makers learning from international experience and refining their current programs. As China is increasing important in global leadership of environmental affairs (Guttman et al. 2018), it is essential for the world to understand of how western PES concept is translated into a China context. China's ongoing eco-compensation and policy

innovations could enlarge the scope of PES and provide valuable lessons for international policymakers and practitioners.

5.3 Methods for ecosystem service governance

The institutional analysis of PES is challenging due to the complex settings, diversity of actors and dynamic nature of social-ecological systems. Therefore, the analysis of governance solutions calls for interdisciplinary and participatory approaches. A method review from our colleagues (Sattler et al. 2018) showed that less interdisciplinary methods are applied to justify the complex issues of ecosystem service governance, with few participatory methods being used to encourage stakeholder engagement. My experience has shown that mixed approaches combining qualitative and quantitative methods, such as QCA and SNA, have great potential for filling in the gaps. Despite being well-established tools in their own disciplines, the application of the two methods in the field of environmental governance is rare.

5.3.1 QCA in determining institutional conditions

As a formalized way of determining preferred environmental governance structures, QCA offers great opportunities for analyzing existing governance approaches and supporting implementation, monitoring, and evaluation. In order to address research object B1, this dissertation has shown that QCA provides an excellent tool for translating institutional complexity into reduced and comparable arrangements, and for formulating inferences on policy design.

QCA could be very helpful in determining whether certain conditions, either individually, in combination or in absence, are sufficient for facilitating the successful implementation of PES (Paper 2). This dissertation also has taken a broader methodological view by explaining how two different QCA methods could be applied to international content (Paper 4). The application of crisp-set QCA (csQCA) and fuzzy-set QCA (fsQCA) to Comparative Institutional Analysis (CIA) are illustrated step by step, based on two case studies from Germany and China. Unlike other methods, particularly quantitative approaches, the QCA method shows combinations of conditions that are relevant for a certain outputs and does not focus on the impact of single conditions. The well-verified and interpreted results provide straightforward

and highly relevant policy implications that can easily be communicated to relevant decision-making bodies and decision makers. The advantages of QCA may be especially relevant in terms of research on PES, which requires a better integration of relations between institutional, socioeconomic and environmental issues.

5.3.2 Net-Map for participatory network mapping

Social network analysis (SNA) is a suitable methodology for uncovering involved actors, their motivations and power relationships, and institutional settings. Addressing to research object B2 this dissertation showed Net-Map, as a tool for SNA, could be strong in understanding institutional interplay and governance model (paper 3). Net-Map can help stakeholders understand, visualize, discuss, monitor, evaluate and improve situations in which many different actors influence outcomes. By creating the network maps, individuals and groups can clarify their own views of a situation, foster discussion, and develop a strategic approach to networking activities.

Net-Map also can be used as a facilitation tool or for research interviews. It is hands-on, low-tech and participatory. Like an “ice-breaker”, the easy-going and playful atmosphere enables the participants to talk freely about their social network, especially informal one. Some institutional aspects, which are traditionally difficult to explore, can be reveal. It addresses several problems that may occur during interviews, such as reaching transparency and common understanding through visualizing the situation, overcoming shyness (Paper 5). It can ultimately improve social learning and the quality of interview data (Schiffer and Waale, 2008; Campbell et al., 2014).

5.4 Overall limitations

5.4.1 The design of governmental PES

This dissertation has contributed to narrowing the gap between international PES concepts and the Chinese practice of eco-compensation. While the SLCP is a major component in China’s ecological conservation policy, it cannot wholly represent the image of governmental PES in China. As most implications of this dissertation are based SLCP, some features of other eco-compensation programmes might be overseen. For example, this dissertation focused on only forest ecosystem services.

However, other ecological programs, such as watershed compensation schemes, may contribute differently. Future research should identify links between institutional settings with other programs as well as different instruments (such as auctions and credits). Furthermore, the theoretical re-framing of PES with incomplete institutional settings has not yet been compared with other countries.

The sample size of my case study is relatively small, as Paper 2 includes 59 households and Paper 3 includes 31 interviews with stakeholders. All the case studies are in Jingyuan County, from the Guyuan Region of the Ningxia Hui Autonomous Region. The results show that environmental effectiveness is different among households and townships, where institutional settings and local dynamics played important roles. However, these findings need to be further investigated, with a larger number of samples size and in a larger scale, if someone seeks to analyse more generalized implications for China and the world. The case studies carried out in this dissertation, however, have wide relevance for the understanding of eco-compensation and PES in China, as other regions which had implemented the same program shared similar stories.

Some other institutional elements, such as trust, norms and traditions, may have been underestimated in the dissertation. Trust is the cornerstone of cooperation and public goods provision. While trust was only partially addressed in Paper 3, norms and tradition were left out in this dissertation. Adding them to the institutional settings could provide more holistic insights.

Finally, this dissertation has taken a static point of view to look at institutional settings. However, the forest sector in China is experiencing rapid institutional transformations and modernization, including tenure reform, logging bans and administrative structural changes. Further study could focus on the interplay between institutional changes and PES implementation.

5.4.2 Methodological limitations

I consider QCA and SNA alternative or complementary methods to conventional research approaches. This dissertation has no intention to argue that QCA and SNA are substitutions for the traditional qualitative and quantitative approaches (such as statistic and regression analysis). Therefore, this dissertation had not offered a

comparison between the “new” and “old” methods. Future efforts on integrated evaluation methods on the ecosystem services governance approaches are highly recommended.

Some attention should be paid to the backdrop of QCA and SNA. QCA has been criticized for reduced case numbers, limited causal conditions (Rihoux and Lobe 2009), subjective condition selection and imperfect calibration (Basurto and Speer 2012). Similarly to other case-oriented studies, QCA faces the same challenge of only a limited number of cases and conditions being considered. Having many cases and conditions may affect the result. Moreover, the selection of cases and conditions has a strong impact on the results of the research. The selection must be based on careful consideration and strong arguments, in order to avoid subjectivity. As a key part of fsQCA, calibration is essential for the reliability and replicability of the result. Therefore, it needs to be done carefully, documented clearly and in great detail. During the review process of paper 2, the subjectivity of condition selection was criticized by the reviewers and my experience showed that it demands lots of efforts to convince the reviewers.

For conducting Net-Map interviews, researchers have to consider the specific settings of the case study they want to investigate, especially regarding power relations and the distribution of knowledge. In contexts with strong hierarchies, the method becomes more difficult to apply. Local actors are not used to answering open questions, or do not have enough information due to poor participation in the design of the governance models. Only people with hierarchical power are capable of sharing information. Also, it was difficult to encourage people to guess about the other actors involved in this context, as well as links and influence from social spheres other than their own. Actors are not genuinely interested in clearly addressing power structures, and dependent actors do not feel free to evaluate others in their network. Therefore, the application of this method in highly hierarchical settings should be carefully considered. Further researches are encouraged with regarding power relationships and knowledge hierarchies in different social and institutional settings.

6 Conclusion

This doctoral dissertation contributes to existing knowledge of institutional analysis of governmental PES by addressing two central objectives. The institutional design of a governmental PES program has been examined in China, and new methods for ES governance analysis have been discussed in an international context.

This dissertation has shown that current western PES theory is not robust enough to capture the realities of what is happening for ES governance in China, where government is the predominant player, the property rights are separated and western distinctions among public sector, private sector, and civil society are not clearly applicable.

The concept of PES is partially employed in China by providing eco-compensation. While the institutional settings might be considered incomplete according to western PES theory, it did not prevent the wide acceptance and rapid development of the major eco-compensation program at the beginning phase. The Chinese government used a combination of regulatory and voluntary manoeuvres to encourage transactions, and local government affiliated or related agencies filled the role of intermediaries. However, this model can not overcome bureaucratic complexity and rent-seeking behavior, and keep households from simply performing one-off acts, and encourage them to make a long-lasting effort. Therefore, the environmental performance in the long-term cannot be ensured in the absence of key PES elements.

Eco-compensation may be an important reference for governmental PES, in which institutional requirements are as important as the designing of specific financial incentives. Some institutional challenges undermine the anticipated advantages of PES, and the path to environmental outcomes has been shaped by local institutional and socioeconomic conditions interacting with broad top-down policies. Governmental PES programs could benefit from adopting widely accepted principles which underly in typical PES, as reflected in policy design, implementation and monitoring.

This dissertation also shows two innovative methods for supporting the research of ecosystem service governance. The QCA can be an excellent way of determining the preferred institutional arrangements for ES governance, while Net-Map tool can be a

flexible tool for understanding governance modes. QCA and Net-Map may be fruitful in PES research, which has been explored via either quantitative or qualitative approaches.

Aiming to close the knowledge gap regarding the combination of voluntary market and hierarchy-based system, this dissertation hopes to offer a better understanding of governmental PES in dealing with incomplete institutional settings.

7 Reference

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8 Eigenständigkeitserklärung

Hiermit erkläre ich, die Dissertation selbstständig und nur unter Verwendung der angegebenen Hilfen und Hilfsmittel angefertigt zu haben. Ich habe mich anderwärts nicht um einen Doktorgrad beworben und besitze keinen entsprechenden Doktorgrad.

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Weiterhin erkläre ich, dass keine Zusammenarbeit mit gewerblichen Promotionsbearbeiterinnen/Promotionsberatern stattgefunden hat und dass die Grundsätze der Humboldt-Universität zu Berlin zur Sicherung guter wissenschaftlicher Praxis eingehalten wurden.

Statutory declaration:

I hereby declare that I completed the doctoral thesis independently based on the stated resources and aids. I have not applied for a doctoral degree elsewhere and do not have a corresponding doctoral degree.

I have not submitted the doctoral thesis, or parts of it, to another academic institution and the thesis has not been accepted or rejected. I declare that I have acknowledged the Doctoral Degree Regulations which underlie the procedure of the Faculty of Agricultural and Horticultural Sciences (Humboldt-University), as amended on 14th July 2005.

Furthermore, I declare that no collaboration with commercial doctoral degree supervisors took place, and that the principles of Humboldt-Universität zu Berlin for ensuring good academic practice were abided by.

Berlin, 15.06.2019 Cheng Chen.....

(Unterschrift der Kandidatin/ signature of the candidate)