UNIVERSITÄT BAYREUTH

Economics of Production of Forest Ecosystem Services Multifunctionality and Livelihoods: Institutions, Costs and Community Forestry

Thesis

to attain the academic degree of Doctor of Natural Science (Dr. rer. nat.) of the Bayreuth Graduate School of Mathematical and Natural Sciences (BayNAT) University of Bayreuth

Presented by

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Summary

Sustainable forest management actions enhance the supply of numerous marketed and non-marketed ecosystem services and can improve socio-economic development in the tropics. Currently, there are increasing rate of forest biodiversity and ecosystem services losses due to anthropogenic pressures and ecological risks. There is an increasing demand for various forest ecosystem services for socio-economic development hence the urgent need to identify ways to enhance provisioning of these services and options to balance forest communities' socio-economic development and conservation.

This thesis attempts to provide imperative theoretical and empirical insights into the importance of ecosystem multifunctionality in addressing the undersupply of forest ecosystem services. It investigates research questions that are central to the provisioning of forest ecosystem services and simultaneously enhancing livelihood outcomes in a localised landscape in tropical forests. Analysis of complexities in the economics of production of forest ecosystem services multifunctionality can additionally strengthen sustainable relationship between nature and society.

Multifunctionality production and management processes are complex due to the high non-linear relationships and trade-offs between both inputs and outputs in the management of ecosystems as well as the forest owners' objectives at the stand or forest levels. Linking multifunctionality to ecosystems services concepts are generally underrepresented in the literature to date.

This cumulative thesis addresses these gaps through the five (5) papers which are published in peer review journals.

Paper 1 evaluates cost factors that influence multifuncationality management describing a translog dual cost function and suggests that multiple productions can be implemented without additional costs to private forest owners.

Paper 2 compares forest institutional property rights in two case study countries and evaluates the linkages of institutional property rights to sustainable livelihoods and forest conditions.

Paper 3 assesses empirical evidence on community forestry hypothesis in the supply of multiple ecosystem services and household welfare improvement applying a propensity score matching estimation technique comparing community based conservation association members' vis-à-vis non-members.

Paper 4 discusses multiple conceptualizations of nature as key to inclusivity and legitimacy in global environmental governance by examining the concept of nature in more than sixty (60) languages and identify three clusters: inclusive conceptualizations where humans are viewed as an integral component of nature; non-inclusive conceptualizations where humans are separated from nature; and deifying conceptualizations where nature is understood and experienced within a spiritual dimension.

Paper 5 presents a Strengths Weaknesses Opportunities and Threats (SWOT) analysis of the ecosystem services framework and proposes five strategic areas for developing and implementing ecosystem services mainstreaming.

The thesis contributes to the current advances in conceptualising ecosystem services framework recognising that the incorporation of production of forest ecosystem services multifunctionality in global ecosystem services research could address several challenges in ecosystem services undersupply. The thesis establishes a stronger relationship between joint ecosystem services provisioning and livelihoods.

Three identified considerations and conditions to affirm sustainable forest ecosystem services multifunctionality are (1) securing forest institutional property rights, (2) production and cost structure estimation and (3) engaging community-based conservation groups.

Zusammenfassung

Maßnahmen für eine nachhaltige Waldbewirtschaftung erweitern das Angebot zahlreicher markt- und nichtmarktvermittelnder Ökosystemdienstleistungen und können die sozioökonomische Entwicklung in den Tropen verbessern. Aufgrund anthropogener Belastungen und ökologischer Risiken sinkt derzeit die biologische Vielfalt und Verluste von Ökosystemdienstleistungen steigen stetig. Deshalb müssen dringend Wege gefunden werden, die Bereitstellung dieser Dienstleistungen zu verbessern. Darüber hinaus müssen Möglichkeiten ausgeleuchtet werden, die eine Ausgewogenheit zwischen der sozioökonomischen Entwicklung und der Erhaltung von Ökosystemen schaffen. Für die sozioökonomische Entwicklung entsteht ein steigender Bedarf für verschiedene Dienstleistungen des Waldökosystems.

Die vorliegende Forschungsarbeit versucht entscheidende theoretische und empirische Erkenntnisse über die Bedeutung der Multifunktionalität des Ökosystems zu liefern, um die Herausforderungen der Unterversorgung von Ökosystemdienstleistungen zu bewältigen. Es werden Forschungsfragen analysiert, die für die Steigerung der Produktion von Ökosystemdienstleistungen des Waldes und gleichzeitig für die Verbesserung der Existenzgrundlage in einer lokalisierten Landschaft in den Tropen von zentraler Bedeutung sind..

Analysiert man die Komplexität der Wirtschaftlichkeit in der Produktion von Ökosystemdienstleistungen des Waldes und der Multifunktionalität dieser Systeme, zeigt sich, dass die Beziehung zwischen Natur und Gesellschaft aufgewertet wird.

Produktions- und Managementprozesse sind aufgrund der ausgeprägten nichtlinearen Beziehungen komplex. Weitere Ursachen der Komplexität liegen in dem Zielkonflikt des Ökosystemmanagements zwischen Inputs und Outputs sowie in den Zielvorgaben der Waldbesitzer auf Waldstück oder ebene. Die Verknüpfung von Multifunktionalität mit Dienstleistungskonzepten des Ökosystems ist in der Literatur im Allgemeinen unterrepräsentiert.

Die zusammenfassende Forschungsarbeit schließt diese Lücken mit fünf (5) wissenschaftlichen Abhandlungen, von denen vier (4) veröffentlicht wurden, ein Teil wird derzeit überprüft:

Der erste Arbeit (1) analysiert Kostenfaktoren, die das Multifunktionalitätsmanagement beeinflussen und eine Translog-Dual-Cost-Funktion beschreiben. Die Analyse deutet darauf hin, dass mehrere Produktionen ohne zusätzliche Kosten für private Waldbesitzer implementiert werden können.

In der zweiten Arbeit (2) werden institutionelle Eigentumsrechte in zwei Fallstudienländern miteinander verglichen und die Verknüpfung institutioneller Eigentumsrechte mit nachhaltigen Lebensgrundlagen und Waldbedingungen evaluiert.

Die dritte Arbeit (3) bewertet empirische Belege für die „Gemeinschaftliche Forstwirtschaft Hypothese" bei der Bereitstellung mehrerer Ökosystemleistungen und der Verbesserung des Gemeinwohls mit Hilfe einer Schätztechnik (Propensity Score Maching). Bei dieser Technik werden die Mitglieder einer gemeindebasierten Naturschutzvereinigung gegenüber Nichtmitgliedern verglichen.

In der vierten. Arbeit (4) werden mehrere Konzeptualisierungen der Natur als Schlüssel zur Inklusivität und Legitimität in der globalen Umweltpolitik diskutiert, indem Natur in mehr als 60 Sprachen untersucht und drei Cluster identifiziert wird: Inklusive Konzeptualisierungen, bei denen Menschen als integraler Bestandteil der Natur gesehen werden; nicht-inklusive Konzeptualisierungen, bei denen der Mensch von der Natur getrennt ist; und vereinigende Konzeptualisierungen, wo die Natur innerhalb einer spirituellen Dimension verstanden und erfahren wird.

In der fünften Arbeit (5) wird eine SWOT- Analyse (Stärke, Schwäche, Chancen und Risiken) für den Rahmen von Ökosystemdienstleistungen durchgeführt. Fünf strategische Bereiche für die Entwicklung und Implementierung von Ökosystemdienstleistungen werden vorgeschlagen.

Die Forschungsarbeit trägt zu den aktuellen Fortschritten der Konzeption von Ökosystemdienstleistungen bei, in denen anerkannt wird, dass durch die Einbeziehung der Produktion von multifunktionalen Ökosystemdienstleistungen des Waldes in die globale Ökosystemdienstleistungsforschung, verschiedene Perspektiven der Dienstleistungsunterversorgung beleuchtet werden.Die vorliegende Abhandlung stellt eine stärkere Beziehung zwischen ökosystemischen Dienstleistungen und Existenzgrundlagen her.

Drei identifizierte Überlegungen und Bedingungen zur Gewährleistung nachhaltiger multifunktionaler Waldökosystemleistungen sind (1) die Sicherung institutioneller

Waldeigentumsrechte, (2) die Schätzung der Produktions- und Kostenstruktur und (3) die Einbeziehung gemeinschaftsbasierter Naturschutzgruppen.

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Declaration of Own Contributions to the Papers in the Thesis

This cumulative thesis includes five (5) published papers. The papers are classified into two categories: “conceptual and review" and “empirical". The contribution to each paper is divided into three sections: (i) concept and discussion, (ii) data collection and analysis, and (iii) writing. “Concept and discussion" is understood as the initialisation of research ideas, provision of comments/suggestions, and proof-reading. “Data collection" is understood as the design and actual participation in the collection and analysis of the data, including secondary data for the paper. “Writing" is understood as the actual formulation of sentences and paragraphs.

Paper	Categories	Concept and discussion (%)	Data collection and analysis (%)	Writing (%)
Paper 1:	Empirical	90	100	100
Paper 2:	Empirical	90	100	100
Paper 3:	Empirical	90	100	100
Paper 4:	Conceptual and review	50	40	40
Paper 5:	Conceptual and review	50	90	100

I am the first and corresponding author of three papers (numbers 1, 2, and 3). Co-authors of two conceptual and review papers (numbers 4 and 5). Papers 1 and 2 were published in top forest and ecological economics journals (Forest Policy and Economics - IF of 3.099 and Ecological Economics - IF of 4.281). Paper 3 is published in a forestry journal (Journal of Sustainable Forestry - IF of 1.242). Paper 4 was published in an interdisciplinary journal linking environmental issues with social and economic issues (Environmental Science and Policy - IF of 4.816). The last “conceptual and review" Paper 5 was published in a high ranking international and interdisciplinary journal that deals with the science, policy and practice of Ecosystem (Ecosystem Services - IF of 5.572).

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List of Abbreviations

CBCAs	Community Based Conservation Associations
CFAs	Community Forest Associations
ES	Ecosystem Services
FES	Forest Ecosystem Services
FESM	Forest Ecosystem Services Multifunctionality
FPRI	Forest Property Rights Institutions
ILK	Indigenous and Local Knowledge
IF	Impact Factor
IPBES	Intergovernmental Platform for Biodiversity Ecosystem Services
NCPs	Nature's Contributions to People
NIE	New Institutional Economics
NTFPs	Non-Timber Forest Products
PFPD	Provincial Forest Protection Department
SDGs	Sustainable Development Goals
SLF	Sustainable Livelihoods Framework
SRAs	Social Responsibility Agreements
SWOT	Strengths-Weaknesses- Opportunities-Threats
TEEB	The Economics of Ecosystems and Biodiversity
TUPs	Timber Utilisation Permits
WCAs	Wildlife Conservation Associations
YESS	Young Ecosystem Services Specialists

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Dedication

This thesis is dedicated to my parents Mr. and Mrs. Lambini Kombat and our daughter Yenumi Salomé Kombat Lambini.

I love you, sunshine!

Chapter 1
Introduction

1.1 Problem statement and research motivation

Forests are widely acknowledged as being principle ecosystem service providers. They provide critical and multiple ecosystem services, including timber and non-timber forest products (ntfps), recreational values, above and below carbon storage, erosion control and soil nutrient retention, underground water storage and quality regulation, biodiversity conservation and livelihoods among many others as shown in Figure 1.1.

These forest ecosystem services are important, however undervalued assets in addressing two of the most significant challenges of our time: climate change and socio-economic development challenges. Forest ecosystem services can contribute to the achievements of the Sustainable Development Goals (SDGs), and other international environmental agreements (for example the Paris Climate Agreement and Convention on Biological Diversity).

However, forest ecosystem services are undervalued, forest biodiversity and ecosystems continue to decline at unprecedented rates in human history and the rate of species extinction is accelerating with grave impacts on forest communities (IPBES, 2019; Marquet et al., 2019). Forest ecosystems degradation and the loss of biodiversity undermine ecosystems functioning and resilience and thus threaten their ability to continuously supply the flow of multiple ecosystem services for present and future generations. These threats are expected to become even greater in the context of climate change (Nguyen, 2015) and ever increasing human consumption of forest resources. Forest biodiversity and ecosystem services can no longer be treated as free goods and services and inexhaustible. They have instrumental, intrinsic and relational values to society. Costs of their rapid degradation and extinction and available integrated options to address challenges of sustainable multiple management of ecosystem services and socio-economic livelihoods of forest communities need to be assessed and evaluated critically in ecosystem services science.

One of the major challenges of ecosystem services science is determining how to manage multiple services at the same time increasing livelihoods of providers of these services. Analysing the options to balance production of forest ecosystem services multifunctionality entails grasping the full concept and framework of ecosystem services.

Attempts to advance ecosystem service science and policy research has often been engulfed with multiple debates on conceptual and analytical frameworks for example, (1) natural assets and human well-being based on the four main categories of Millennium Ecosystem Analysis: provisioning, regulating, supporting and cultural services (MEA, 2005), (2) complex interconnected social-ecological systems (dynamic interdependent nature of society and ecosystems (Ostrom, 2009; Schoon and van der Leeuw 2015), (3) economic conceptualisation of multiple ecosystem service values (TEEB, 2010; Costanza et al., 2017) and (4) IPBES-Nature's Contributions to People (NCP) interpreting ecosystem services more broadly across different cultural, environmental and socio-economic contexts, allowing for both generalising (i.e. scientific) as well as more context-specific (e.g. indigenous and local knowledge) perspectives (Pascual et al., 2017).

The first motivation of this thesis seeks to contribute to the debate on multiple conceptual and analytical frameworks in forest ecosystem services by underscoring the challenges in diverse conceptualizations and how to enhance it inclusive operationalisation and legitimacy in ecosystem governance. This is because recent reviews and analysis of the concept show the scientific challenge in assessing production of forest ecosystem services and livelihoods, as production, uses and benefits of these services to society are highly dynamic, complex and interdependent in many diverse ways, ranging from complementary, competitive and mutually exclusionary ones.

To date there has been limited assessments in the forest ecosystem services and economics literature on how to sustainably manage these multiple forest ecosystem services in the tropics and options to balance its provisioning with livelihood outcomes in rural landscapes at smaller scales (de Groot et al., 2010; Nguyen et al., 2013; Yeon-Su et al., 2018). Better understanding of localised production of multiple forest ecosystem services can help balance landscape and local level needs in forest communities. This thesis attempts to answer these questions on how to balance sustainable production of multiple forest ecosystem services and livelihoods of forest communities.

Forest multifunctionality assessment is confronted with the challenge on how to design an effective and efficient incentive mechanism to engage with private households and community based forest groups in the management and provisioning of services and sustainability of livelihood outcomes in communities. This is due to their inherent complexities in internalising externalities.

Despite a wealth of accumulated literature in the theoretical and experimental fields in relation to payments for forest ecosystem services, there is still a considerable lack of empirical studies evaluating the structure of production and cost of provisioning of joint forest ecosystem services (both marketed and non-marketed services). Therefore, determining the cost structure of joint production of ecosystem services can provide useful information in the designing and implementation of regulations and subsidies.

The second key motivation of this thesis is to analyse the options for incentivising forest ecosystem services multifunctionality including sustainable livelihoods options. Incentives and payment mechanisms based on production and cost structure of joint supply of ecosystem services are not sufficient in ensuring sustainable management and supply of multifunctionality hence the need for an analysis on institutional property rights and community forestry as a plausible panacea in sustainable forest management and joint production of ecosystem services and livelihoods of forest communities (Tucker, 2010). Forest management outcomes (provisioning of multiple ecosystem services and socio-economic livelihoods) depend on the local context and effectiveness of the present form of institutional arrangements.

The third and last motivation that this thesis contributes is by further answering questions on the role of forest institutions and community forestry in the provisioning of forest ecosystem services and livelihood outcomes.

The next sections of the introductory chapter include (i) a theoretical and state- of -the-art literature review section reviewing the concepts of forest ecosystem services and other key concepts underpinning this thesis and (ii) an overall research design and methodology detailing thesis objectives, guiding hypothesis and research questions answered.

After the introduction chapter, the next chapters present the five papers based on which this thesis is written. Finally, a synopsis chapter is presented in Chapter 7 with a short outlook for future research on forest ecosystem services multifunctionality.

1.2 Theoretical Considerations and State-of-the-art Literature Review

1.2.1 Understanding Ecosystem Services and Forest Multifunctionality

The concept of "ecosystem services" was primarily introduced by Ehrlich and Ehrlich (1981), the concept's origin of the modern history dates back to the late 1960s and 1970s, highlighting the societal value on nature's functions (King, 1966).

In the 1970s, the concept already started to point out societal and economic dependence on natural assets in order to attract public interest on biodiversity conservation (e.g. Westman, 1977). The book by Daily, 1997 (Nature's Services: Societal Dependence on Natural Ecosystems) marks an important milestone in the mainstreaming of ecosystem services.

Recent years have witnessed a proliferation of research on the concept of ecosystem services (IPBES, 2019; Marquet et al., 2019). Ecosystem Services (ES) framework have been considered one of the most prominent approaches towards conservation nowadays (Kull et al., 2015; Kadykalo et al., 2019; Daly, 2020). The concept offers a valuable approach in linking human and nature, and arguments for the conservation of multiple forest ecosystem services and sustainable livelihoods. The utilitarian framing of beneficial ecosystem functions as services in order to increase public interest in biodiversity conservation dates back to the 1970s (de Groot, 1987).

The mainstreaming of the literature continuous to the 1990s with increased interest on methodological approaches to value and sustain the supply of these services. Since the Millennium Ecosystem Assessment was launched in 2005 grouping services into four broad categories of provisioning, regulating, cultural and supporting, there have been sustained efforts to assess changes in biodiversity and ecosystem services and putting the concept firmly on the conservation and development policy agenda (Fisher et al., 2009). The concept has turned into a political instrument to achieve sustainable use of natural resources for sustained ecosystem services supply and livelihood sustainability based on scientific evidence (Aznar-Sánchez et al., 2018).

Conservation and development has a history of plural views driving different concepts and frameworks and these debates are reflected in the current discourse on ecosystem services (Holmes, 2015). The relationship between people and nature has been experienced and analysed in multiple ways throughout human history and considerable heterogeneity still exists between cultures (Mace, 2014). Various ecosystem services frameworks and classifications have been examined in the literature, such as MEA in 2005 classifying services into twenty two (22) under four groups: provisioning, regulating, cultural and supporting. TEEB (2010) equally uses a classifcation that includes twenty two (22) ecosystem services and grouped into four main categories: provisioning, regulating, habitat, and cultural and amenity.

The literature have highlighted a wider range of values (instrumental, relational and intrinsic values) and the use of different assessment methods (ecological, economic, socio-cultural methods or a mixed of these), and worldviews (indigenous and local knowledge (ILK) systems).

Most of these classifications in the literature focused mainly on economic values. Ecosystem services valuation methods have been criticized over a limited scope and over-emphasis in distinguishing only two value dimensions: intrinsic and instrumental values, prone to anthropocentricism. A focus on instrumental and intrinsic values risks impeding the recognition of value pluralism (Jacobs et al., 2016). Since TEEB (2010), a wider ecosystem services science and policy debate has been developing on how to move beyond a focus on economic values to one that also examines more diverse conceptualisations of values, valuation methods, and worldviews (Arias-Arevalo et al., 2018; Braat 2018). The dabate has further raised concerns that ecosystem services concepts and frameworks have predominantly focused on western scientific concepts of services, and as such often fail to account for the preferences and values associated with indigenous and local knowledge (ILK) systems (Díaz et al., 2018; Kirchhoff, 2019).

A review of the concept shows some important contributions to sustainable human-nature interactions and improving conservation and development. This is based on its advances in the conservation literature, holistic aspects of the framework, broader stakeholder engagement and as an effective tool for communication. However, the concept still has numerous limitations that need to be addressed. These include (i) lack of consideration of differences between diverse languages, worldviews and cultures, ambiguous terminologies associated with the concept and (ii) incomplete understanding of their multifunctionality and trade-offs, and additionally, complexities linked to ecological-socio-economic interactions in the concept, competing approaches to ecosystem services sustainability and scale-dependency issues among others.

The Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (IPBES) was established with the aim to ‘strengthen the science-policy interface for biodiversity and ecosystem services for the conservation and sustainable use of biodiversity, long-term human well-being and sustainable development’. “Nature’s contributions to people” (NCP) conceptual framework coined by IPBES and aimed to account for some of these concept limitations raised above, explicitly acknowledging the wider conceptualizations of values and valuation (Pascual et al., 2017). The NCP framework further integrates instrumental, intrinsic and relational values to society and epistemologically, ontologically and methodologically more pluralistic than ecosystem services concept. Most NCP straddle across the categories of material, non-material and regulating contributions (Diaz et al., 2018). It is important to state that the NCP conceptual framework has however received critics questioning whether the adoption of the NCP terminology is useful in terms of effectively embracing a wider conceptualisation of values than is currently incorporated within the concept of ecosystem services (de Groot et al., 2018; Kenter, 2018; Maes et al., 2018; Faith, 2018). Their arguments conclude that ecosystem services concept has inherent semantic limitations and a single framework cannot fully address all diverse issues and problems nature and society faces. Furthermore, the NCP concept is not sufficiently formalised and validated in practice and with very little operational guidance on the application or assessments of NCP beyond rather common indicators (Kadykalo et al., 2019).

Some experts suggest a return to the less constraining notions of “nature's functions and services,” without a necessary tie to ecosystems in the conceptual debate as the current focus on ecosystems is more a liability than an asset in the field hence a call to move away from that of “ecosystem” services (Baveye et al., 2018). This suggestion confirms earlier works of Westman (in 1977) who perceived nature through the lens of a broadly-defined concept of “ecosystem,” but did not see the need to invoke this concept when referring to the benefits humans derive from nature.

Assessing forest ecosystem services multifunctionality in ecosystem services debate is necessary and has advantages for sustainable conservation management because multiple functions are required to deliver the numerous ecosystem services that humans require from nature *(Manning et al., 2018, 2019). Forest ecosystem services as well characterises the interdependence of quality of life and the environment. Forests simultaneously generate multiple services including livelihoods, although it is generally not possible to manage these ecosystems to simultaneously maximize all services, and as a result trade-off occur (Smith et al., 2012; Herzig et al., 2018).

The graphic in Figure 1.1 shows the complex interdependence between marketed and non-marketed forest services in a localised landscape. The figure appreciates and recognises the diverse views on ecosystem services concepts and frameworks as reflected in the current discourse. The multiple services outlined consider the instrumental, intrinsic and relational values as recommended in “Nature’s contributions to people” (NCP) framework. The listed services are not exhaustive, other ecosystem services could also be considered depending on the forest landscape type.

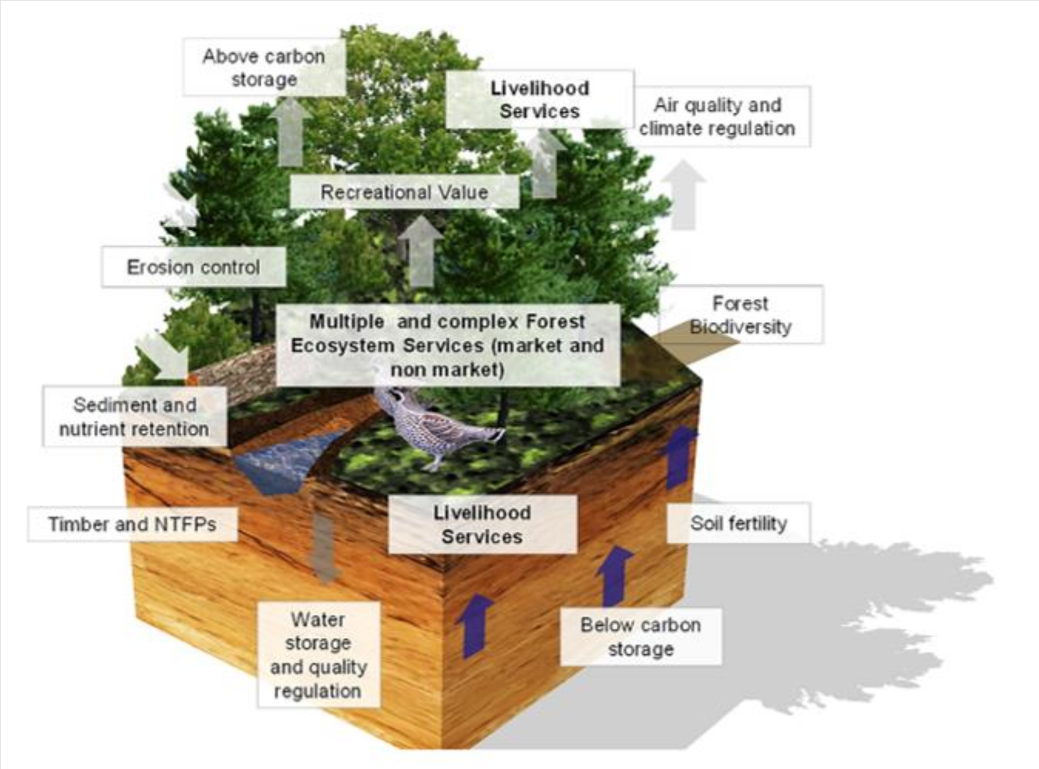

Figure 1.1 Forest Ecosystem Services Multifunctionality (FESM) -Author's construct based on (Lambini et al., 2018).

Different forest land uses and management decisions lead to an increase in one service and a decrease in some other service(s). Forest multifunctionality can generate conflicts in natural resource management, development, and planning. These conflicts are due to divergent preferences held by different service producers and users (Martín-López et al., 2012). Joint production of these ecosystem services depends on the management regime and practices, technical interdependency, fixed non-allocable inputs and outputs competing for an allocable input (Hodge, 2008).

Understanding the technology and practices could shape the production possibility frontier in the given forest land use and navigate the trade-offs and conflicts with other services and livelihood outcomes.

Given the landscape of diverse concepts, typologies and framings of ecosystem services concept, the concept implementation and practical concerns, this thesis reviews the current Ecosystem Services concept–searching for gaps, suggesting how to fill these gaps and considering the extent to which this approach remains fit for purpose in the forest economics literature.

1.2.2 Institutional Property Rights

Institutions have been the subject of abundant research in forest sustainability science (Hassan et al., 2020). They are means to reduce transaction and information costs based on choice theoretical approach and coordinate economic activities through formal or informal means (North, 1990; Coase, 1960). Property rights on the other hand function as a guiding incentive in internalising externalities. Feeny et al., (1990) for example classify four basic property right regimes in resource management: (1) open access, (2) communal property, (3) private property, and (4) state property. These rights are defined as the exclusive rights over a resource or over the attributes of a resource and emerge when it becomes economically relevant to those affected by externalities.

Ostrom (2005) concludes that the absence of property rights leads to resource depletion hence users of resources could organise themselves and create rules that define their rights. Ostrom (1990) suggests eight design principles, positing them to characterise robust institutions for managing common-pool resources. These principles contribute to understanding the free rider problem, even without a state or formal rules.

Cleaver's (2002) 'institutional bricolage' provides further insight into which institutions matter for natural resource governance and livelihoods by demonstrating how people piece together new institutions from existing institutions, whether formal or informal, to gain and maintain access to resources.

Institutional property rights constitute all formal and informal rules in a given forest management condition and include management institutional environment and arrangements (Lambini and Nguyen, 2015; Hassan et al., 2020). These rights provide understanding of the variety of rules and arrangements that have evolved in different societies to govern the relation between people and nature (Fremier et al., 2013).

There are several empirical assessments reviewing effectiveness of institutional property rights in forest management (June et al., 2019). Stankey and Clark (1992) in their paper 'Social aspects of new perspectives in forestry: a problem analysis' focused on the relationship between social values and new approaches to forest land use and management. They identified topics that need further research, including: integration of institutions and social values; understanding public values for resources and public acceptability of forest management approaches.

Conclusions on institutional outcomes in forest management are mixed, with some experts claiming that, forest institutional property rights have positive role in forest poverty reduction and ecosystem services management (Dimitrov, 2005; Hough, 2003). However, others suggest that securing forest institutions negatively influence ecosystem services management in some developing countries (Sikor and To, 2011; Larson et al., 2012).

Studies linking forest institutional property rights and ecosystem services and livelihoods are few (Pritchard et al., 2000; Larson et al., 2012; Cortner et al., 1998; June et al., 2019). Most of these studies rather analyze institutional requirements for payment of ecosystem services (PES) and not as a requirement for managing forest lands for provisioning of services and livelihoods. Börner et al., (2017) point to the importance of accounting for locally specific contextual dimensions (e.g. politics, institutions, pre-existing policies) in PES project design. Locatelli et al., (2014) highlight the potential for PES to destabilize local institutions. For example, according to Ishihara et al., (2017), it is essential to analyse another layer of socio-ecological complexity: agency and power relations that arise from PES. Ecosystem service providers become ‘institutional bricoleurs’ who draw on social and cultural arrangements and institutional contexts to build new institutions that are adapted to their local contexts (Ishihara et al., 2017). Institutional bricolage thus challenges the view of actors as powerless victims of institutional change. These studies do not sufficiently address institutional issues on ecosystem services management. The Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services’ (IPBES) conceptual framework highlights the central role that institutions play in ecosystem services management (IPBES, 2019) and advocate for institutions as a key driver in the supply of services. Designing institutions in ecosystem services science is however necessary but difficult process. Several limitations are identified with institutional property rights juxtaposed to forest ecosystem services management.

Management and production of multiple forest ecosystem services from a localized landscape are highly complicated given the fact that their production cross political and jurisdictional boundaries, it is difficult and impossible to find an ecosystem service solely produced on a single forest owner’s land. The multiple scales of forest ecosystem production require cooperation among a broad range of stakeholders and a secured functioning institutional property right. A significant challenge is how to design institutions and approaches to manage these complex boundaries. Ecosystem services governance is fundamental and determines interrelationships between services. Most governance approaches lack an understanding of institutional contexts which determine specific driving factors for services supply.

Cortner et al., (1998), identified problem areas where improved understanding of the institutional issues associated with forest ecosystem management is needed. In their study, they specify that the current theoretical and methodological approaches in addressing institutional questions are insufficient in reaching the goals of forest multifunctionality.

An additional major management institutional barrier identified is how these management regimes could enhance multiple ecosystem services production including livelihoods and internalizing management cost efficiency. Institutions are embedded in ecosystem management structures and crucial in management processes, hence can significantly influence joint supply of ecosystem services. As a result, there is a growing need for a new institutional property right arrangement at local landscape scale for effective management of forest ecosystems. The new element is represented for example by tenure systems that specify rights of access to multiple ecosystem management (Hanna, 1998).

1.2.3 Sustainable Livelihoods and Forest Ecosystem Services

Ecosystem services concept has reached global prominence for describing and evaluating the interdependence of ecosystems and human well-being. The concept focuses on both ecological production functions (e.g biodiversity conservation, carbon sequestration, erosion control) and recognises anthropocentric values (e.g. provisioning of livelihood outcomes and societal benefits). The basic premise is that ecosystems and humans exist as coupled systems, in which ecosystems contain many forms of natural capital that can generate flows of goods and services that benefit people. The various classifications and frameworks examined in the literature discuss and recognise the role of ecosystem services to human well - being highlighting various values (instrumental, relational and intrinsic values). The recent and widely used IPBES "Nature's contributions to people" (NCP) conceptual framework categorises material, non-material and regulating contributions (Diaz et al., 2018) and recognises natures contributions to society.

The profound contributions of forest ecosystems are particularly very high in most developing countries where local population heavily depend on nature for livelihoods (see for example Nguyen et al., 2015, 2018 for Cambodia and Laos). However, these contributions and benefits (e.g principal sources of income and livelihoods) derived from forestry come at a huge cost. The recent IPBES global assessment paints a clearer picture on how human action is alternating nature at a truly planetary scale with impacts that are distributed very unequally. Anthropogenic impacts on forest ecosystems have increased to an extensively alarming level than in any comparable period of time in human history (Diaz et al., 2019). Current rates and magnitude of environmental and social change are straining and increasingly undermining the productivity and sustainability of small-scale forest resource-dependent livelihood systems worldwide. The scale and rates of environmental, social, and economic change are undermining the sustainability of many rural communities that depend directly on forest resources for their livelihoods.

The general assumption that ecosystem services will enhance human well-being was an early argument in the history of the concept, based on a generic idea that, society depend on earth's life support systems, and nature contributes to our aggregate well-being (Daw et al., 2011; King et al., 2019). Production of multiple ecosystem services and benefits are highly conflicting and locally produced according to beneficiaries' capacities and assets, or when they contribute differently to people's livelihoods, conserving or enhancing natural capital does not necessarily enhance well-being for everyone (Berbés-Blázquez et al., 2016). This is a major source of discrepancy between well-intentioned interventions and the realities that materialize for rural poor (Tauro et al., 2018). Studies of phenomena such as sudden collapses of ecosystems (Levin, 1998), economic poverty traps (Lade, 2017) and varying capacities to adapt (Dietz et al., 2003), have adopted ecosystem services and adaptation concepts and methods to generate more nuanced understandings of domain-specific complexities. Despite the broad utility and impact of the concept (Costanza et al ., 2017; Polasky and Segerson, 2009), the application of the concept in small-scale forest resource-dependent livelihood systems has been criticised for under representing key social dimensions (Lele, 2013) and neglected multifunctional benefits co-production (livelihoods and ecosystem services).

Responding to these challenges and complexities, some scholars have recently suggested the incorporation of livelihood activities in joint production of ecosystem services including livelihoods and socio-economic outputs (Martín-López, 2019; Huq et al., 2020; Spangenberg et al., 2014; Fedele et al., 2017). The recent proposal of Ecosystem Services Livelihood Adaptation (ESLA) framework by King et al, 2019 as a comprehensive and research-ready platform for empirical and modelling studies of livelihoods adaptation attempts to address some of the questions on multifuncionality in the thesis. This framework integrates multiple research approaches in order to embrace the complex characteristics of production of ecosystem services and livelihoods outcomes.

Forest ecosystem multifunctionality literature characterises the interdependence of provisioning of joint ecosystem services and livelihoods and seeks to address the complexities that characterize these coupled human-environment systems and their inherent trade-offs (Manning et al., 2018, 2019; McHale et al., 2013). Conservation interventions that do not account for these complexities may be ineffective at fostering adaptation, lead to detrimental outcomes, and generate unexpected environmental and societal tradeoffs (King et al., 2019).

1.2.4 Community Forestry and Forest Ecosystem Services

Forest communities play a significant role in influencing forest management due to their dependence on forest resources for livelihood. For example, land for production, wood for energy and construction, and other nontimber forest products (NTFPs) for consumption and alternative income sources. Several scholars and practitioners (e.g., Agrawal, 2003; Ribot, 2005; Larson, 2005; Blomley, 2013), therefore, suggest that community participation in forest management and engaging local actors is a crucial step towards community development and at the same time improving forest resource management.

Community forestry is viewed as an important pathway towards promoting efficient, effective, transparent and sustainable forest resource use in most tropical forest regions. The forest sector in these regions has witnessed a rapid shift from an earlier centralised state ownership and management to community institutions (Persha et al., 2011; Blomley, 2013). This type of management is often considered as a win-win solution in conservation and development discourse given that a decentralised resource management process empowers local population and communities (Andersson et al., 2008; Agrawal, 2003) and mostly lauded as a relavant strategy to accommodate the rights and needs of communities (Agrawal and Gibson, 1999). Forest management under communities can encompass an array of activities and descriptive labels such as community-based conservation, community based natural resource management, decentralised or participatory resource management and integrated conservation and development initiatives, but with the central idea of “the coexistence of people and nature, as distinct from protectionism and the segregation of people and nature” (Western and Wright, 1994).

Community forestry is characterised by a clear institutional condition with an allowable forest area for communities or household use. Its attributes include implementation of a community benefit sharing mechanism, forest products market linkages and value addition (Duguma et al., 2018).

Numerous scholars (e.g., Kellert et al., 2000; Ayana et al., 2017) suggest that community management addresses the challenges of the centralized management models and reduces deforestation rates in forest communities. Other authors have evaluated the impact of community forestry on socio-economic benefits of local communities and have concluded that community forestry increases household livelihoods and socio-economic outcomes. (e.g., Larson, 2005; Klooster and Masera, 2000).

Most studies found a positive correlation between community forestry and forest resource management (Bray et al., 2008; Nagendra et al. 2008). A number of relevant impact assessments and case studies on community forestry conclude with negative forest conditions and livelihood outcomes (Jumbe and Angelsen 2006; Kassa et al., 2009; Baland et al., 2010). The review of the literature suggests a mixed outcome making the topic on community forestry still a subject of intense debate in forest economics literatures (Lund et al., 2009; Sommerville et al., 2010). Empirical evidence on these outcomes is limited at best, and leans towards livelihood outcomes.

Although there are several empirical studies on community forestry, most of these research focuses on impact assessments of the instrument and the guiding principles on how to establish them to benefit communities. An extensive desk review by Duguma et al., (2018) identified the primary goals of adopting community forestry schemes as: (1) reducing deforestation by transferring management rights to local communities and or by sharing management rights with local communities, and (2) developing pathways of benefiting local communities with the resources located in their proximity. These listed goals emphasise on generating income and other livelihood benefits from for example timber and NTFPs by granting communities access to forest resources. Few empirical assessments have evaluated the distributive effect on joint provisioning of ecosystem services and livelihoods taking into account the issue of timescale, since management may change overtime following an intervention (Seixas and Berkes 2010; Morton et al. 2016; Blomley et al., 2008; Blomley, 2013).

An exhaustive review by Bowler et al., (2012) further found only eight (8) studies made any attempt to control for selection biases in their impact evaluations. Even though ecosystem services and biodiversity conservation are highlighted as co-benefits in community forestry, these services are often not given strong emphasis in community forestry initiatives.

1.3 Research design

As discussed in our review above, there are several theoretical and empirical scientific efforts in managing and sustaining forest ecosystem services within a localised social-ecological system. These studies have clearly contributed to an improved understanding of ecosystem services trade-offs including conceptualisation of the concept and socio-economic valuation of services with inherent limitations in both ecological and economic studies. While these studies have provided fundamental insights into forest ecosystem services science, it is certain that our understanding on how to increase joint production of multiple services with livelihoods is still far incomplete and scarce in the forest economics literature. This is because the sustainable production of forest multifunctionality requires a thorough understanding of their complex interdependent interactions between human's persistent need for ecosystem services and the effects of other variables acting at different temporal and spatial scales in a localised landscape.

Concerns about the increasing degradation of forest ecosystems leading to unprecedented rates of biodiversity loss and enormous threats to several ecosystems, coupled with the high level of poverty in numerous forest communities has recently motivated further research into ecosystem services in addressing some these threats through simultaneous provisioning of multiple functions and services including livelihood outcomes. Assessing multiple ecosystem services simultaneously has advantages for management because multiple functions are required to deliver the many services that humans require from nature (Manning et al., 2018).

Sustainable management of forests could enhance joint production of ecosystem services and simultaneously increase household livelihoods. Although generally joint production is complex due to inherent production trade-offs and consideration of different stakeholder needs in the localised landscape (Smith et al., 2012; Martín-López et al., 2012). Recent studies in ecosystem services advocate for rigorous analysis and consideration of ecosystem multifunctionality in ecological sense and the integration of socio-economic outcomes in forest landscapes. The potential benefits of studying ecosystem services multifunctionality in terms of gaining a holistic understanding of ecosystems, their functions and the production of relevant joint outputs have been clearly identified (Manning et al., 2018; Manning, 2019). Economic analysis and reviews on ecosystem services multifunctionality could reduce the generation of unexpected environmental and societal tradeoffs (King et al., 2019). Multifunctionality analysis in research and practice could be a right step in sustaining human-environmental systems and should be incorporated into ecosystem services science (Díaz et al., 2018) and policy recommendations (IPBES, 2018).

The thesis research design is based on these raised concerns on joint production of forest ecosystem services in the context of multifunctionality in a localised landscape. The overall thesis research framework (Figure 1.2) indicates the relationship between forest institutional property rights and private or community forest management in forest ecosystem services multifunctionality. It additionally shows the holistic perspective in joint provisioning by considering the direct linkages between services and livelihood outcomes. This simplistic diagrammatic framework is hypothesis-driven and limited in fully capturing all relevant issues on multiple production of forest ecosystem services. Nevertheless, it provides a stylised representation and conceptualization on how the thesis was designed and analysed in the context of multifunctionality.

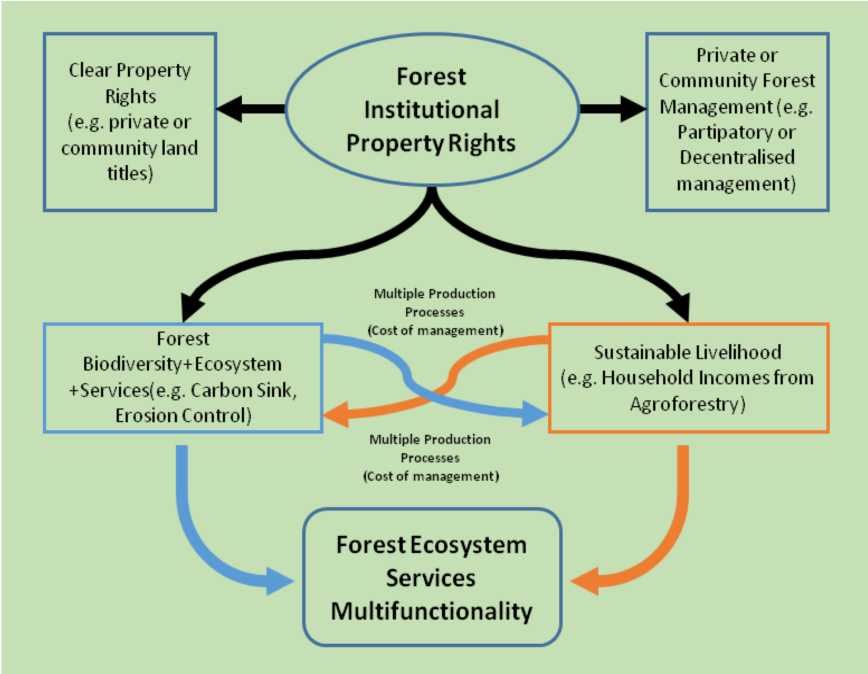

Figure 1.2 **Overall research framework outlining a hypothesis-driven approach to forest ecosystem services multifunctionality.**

The framework shows that forest institutional property rights composed for example with a clear property right to a forest (example private or community land titles coupled with the style of participatory management (private or community forests) influence production processes of forest ecosystem services multifunctionality. Joint provisioning and production processes of both marketed and non-marketed services are impacted by the cost structure in the management of the forest. Multiple production processes in the supply of forest ecosystem services (for example forest carbon sink, erosion control) are expected to frequently interact with sustainable livelihoods (for example household incomes from agro-forestry systems) in the multifuncionality mechanism. This hypothetical framework visualises and assesses how ecosystem services (blue arrows) and sustainable livelihoods (yellow arrows) interact in sustaining a multifunctional landscape in a localised case.

1.3.1 Research objectives, hypothesis and question

There are exponential studies and proliferation of empirical scientific research on management and sustainability of ecosystem services as shown in the literature review of this thesis. However, ecosystem services science till date faces a significant challenge in understanding joint production of forest ecosystem services and at the same time increasing livelihoods of communities. Several research gaps were identified in the thesis as detailed in the state-of- the- art review. These gaps include (i) lack of conceptual clarity in framing ecosystem services and linking forest ecosystem services multifunctionality to ecosystem services concept, (ii) conceptual and methodological challenges which have impeded analyses on joint production of ecosystem services and livelihood outcomes and (iii) lack of substantial evidence on the impact of forest institutional property rights and community forestry on joint supply of forest ecosystem services and livelihoods in forest communities.

The general guiding hypothesis of the thesis is (i) management cost structure, (ii) clear institutional property rights and (iii) engaging in community based forestry significantly increase sustainable joint production of forest ecosystem services and livelihoods.

Multifunctionality production processes are complex and dynamic and provisioning of outputs are highly interdependent. The thesis overall goal is further exploring and analysing options to balance sustainable production of forest ecosystem services multifunctionality.

The guiding research questions in reaching this general goal are:

1. How to understand joint production of forest ecosystem services multifunctionality in ecosystem services conceptualisation?
2. What are the effects of institutional property rights on forest ecosystem services and livelihoods?
3. Is a cost function analysis an appropriate tool to evaluate the production structure of forest ecosystem services multifunctionality?
4. Do Community Based Conservation Associations (CBCAs) households provide forest ecosystem services while contributing to households incomes?

1.3.2 Methodological approach and Study Areas

Given the multifaceted nature of questions discussed in the thesis, a number of research methods were adopted in collecting data and for the analyses. Desk reviews were conducted to collect secondary data on the terms relating to economics of production of forest ecosystem services multifunctionality as shown in (Table 1.1). Secondary information were collected and reviewed especially in the comparative review on institutional property rights in Vietnam and Ghana. Some ecosystem services data were collected through this method to complement on ground ecosystem services production outputs.

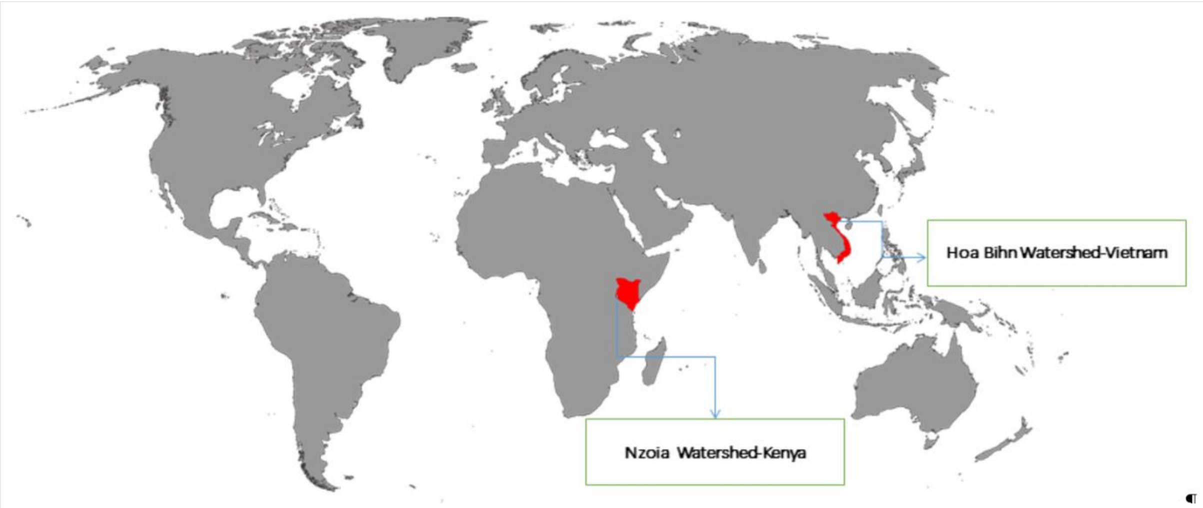

Figure 1.3 Thesis Case Study Countries and Watershed Regions where field research were conducted

Primary data were collected in the fields mainly in Kenya and Vietnam via household surveys and other participatory rural appraisal tools (participant observations, key informant interviews, focus group discussions, transect walks, participatory ecological mappings among others). For the cost analysis in Vietnam, data collection and survey protocols followed two approaches. The first component was to collect data on the cost of forest management and the socio-economic characteristics from a total of 180 private forest owners in the selected districts of the watershed area. The second component covered other relevant data on forest ecosystem services outputs. Data were collected based on a secondary data source from the Vietnam Forestry University and in close partnership with the Hoa Binh Provincial Forest Protection Department (PFPD). Analyses of two competitive Cobb-Douglas cost functions were estimated and in a second step estimated a translog variable cost function.

The study on Community Based Conservation Associations (CBCAs) in Kenya was conducted through household surveys eliciting data from household members of conservation associations and non-member using a sampling technique. A total of 370 households were considered for the impact assessment based on sample adequacy from a total of 1000 households. Out of the 370 households, there were 240 household members belonging to a community based conservation associations (community forestry and wildlife conservation associations). The remaining 130 household members were sampled as counterfactual in the study. Data on ecosystem services outputs were based on literature reviews in the watershed. A propensity score-matching estimation approach was applied to assess causal-inference.

Table 1.1 Terms relating to the economics of production of forest ecosystem services multifunctionality as applied in the thesis

Term	Description	General scope	Case Study Country	Methodological Approach
Multiple Ecosystem Services	Goods and services provided directly or indirectly by nature (positively or negatively) to society including material and non-material services as well as their instrumental, intrinsic and relational values to society	Forest Ecosystem Services	Ghana, Vietnam, Kenya	Ecosystem ServicesAssessments, Analysis of ES concepts and frameworks and Multifunctionality analysis
Institutional Property Rights	Formal and informal governance arrangements in the management of forest ecosystem services and livelihoods. These property rights internalise externalities in forest management.	Forest Cover Conditions and Livelihoods	Ghana and Vietnam	New Institutional Economics (NIE), Analysis of Property Rights
Sustainable Livelihoods	Sustainable Livelihoods as capabilities, assets and activities required for a means of living and able to cope with and recover from stress and shocks. These encompases all individual and household capital assets (natural, social, financial, physical, human and political).	Private household livelihoods and socio-economic conditions	Vietnam and Kenya	Ecosystem Services Livelihood Adaption Framework
Community Forestry	Decentralised management of forest with private individuals and households as a strategy of provisioning of ecosystem services and livelihood	Household incomes, carbon sequestration, biodiversity conservation and erosion control outcomes	Kenya	Community Based Resource Management and Propensity Score Matching Analysis

1.4 Structure of the thesis

The cumulative thesis is structured based on five (5) papers published in peer reviewed journals.

Chapter 1 outlines the thesis problem statement and research motivations. This chapter provides details on the theoretical considerations and state of the art literature review. Research design and methodological approaches to the thesis are further presented. The chapter concludes with major research objectives, guiding hypothesis and research questions that the thesis attempts to answer.

Chapter 2 reviews current literature on forest ecosystem services cost drivers and variables that influence joint production of multiple forest ecosystem services in Hoa Binh Watershed in Vietnam. The chapter describes the theoretical cost function and the empirical model for the dual cost function estimation. It concludes that policies that enhance carbon storage can be implemented without additional costs for private forest owners.

Chapter 3 compares forest institutional property rights in two case study countries and presents the institutional debates relevant in evaluating institutional property rights linkages to sustainable livelihoods and forest conditions. The chapter suggests policies that enhance sustainable forest ecosystem services management in the respective case study countries.

Chapter 4 reviews literature on community forestry hypothesis in multiple supply of ecosystem services and household welfare improvement. The paper applies propensity score matching estimation technique to empirically study community based conservation association members vis-à-vis non-members in the joint supply of ecosystem services and livelihood outcomes.

Chapter 5 discusses multiple conceptualizations of nature as a key to inclusivity and legitimacy in global environmental governance. The chapter examines nature in more than sixty (60) languages and identify three clusters: inclusive conceptualizations where humans are viewed as an integral component of nature; non-inclusive conceptualizations where humans are separated from nature; and deifying conceptualizations where nature is understood and experienced within a spiritual dimension. The chapter concludes that addressing global environmental challenges require improving sustainability imaginaries and co-designing policies and instruments that recognise multifunctionality and inclusive worldviews in ecosystem services science.

Chapter 6 presents a Strengths Weaknesses Opportunities and Threats (SWOT) analysis of the ecosystem services framework uptake through the Young Ecosystem Services Specialists (YESS) members' survey. It proposes five strategic areas for developing and mainstreaming ecosystem services.

Chapter 7 discusses the key conclusions drawn from the five published papers in the thesis. It assesses the thesis limitations, policy options and future research directions in the field of joint production of forest ecosystem services and livelihood outcomes.

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Chapter 2
Paper 1: Are Ecosystem Services Complementary or Competitive? An Econometric Analysis of Cost Functions of Private Forests in Vietnam

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Analysis

Are Ecosystem Services Complementary or Competitive? An Econometric Analysis of Cost Functions of Private Forests in Vietnam

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A R T I C L E I N F O

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A B S T R A C T

Forest ecosystem service (FES) provisioning and management in Vietnam is a priority in the Vietnamese environmental agenda. The main rationale of private forest management is to maximise profits from timber and non-timber forest product (NTFP) production. From a social point of view an under-supply of positive forest externalities (or non-marketed ecosystem services) exists. This paper therefore contributes to the ecosystem service (ES) literature by assessing the production cost structure, in other words, the cost of marketed production and provision of carbon and biodiversity, based on a survey of private forest owners in Hoa Binh Province in Vietnam. The econometric analysis was carried out using a dual cost function approach to analyse the trade-off between forestry costs and ecological performance. This is, to our knowledge, the first time such an approach has been used to estimate the production relationship between marketed outputs and non-marketed ES in the forest sector. This approach appears to be appropriate for handling the multiple joint outputs of forest production and allows us to estimate marginal costs and other cost measures such as cost complementarities in the production of multiple ES. Our results indicate that there is complementarity in the provision of timber and carbon sequestration and, consequently, policies that enhance carbon sequestration in private forests in Vietnam can be implemented without additional costs for the forest owner. We also found that keeping deadwood (to favour biodiversity) had no significant cost and was complementary with NTFP (also an indicator of biodiversity in our study), but could increase the marginal cost of producing timber. This means that biodiversity can be enhanced at no additional cost, provided that the quantity of deadwood does not significantly increase.

1. Introduction

Forest ecosystem services (FES) play an important role in forest management and ecosystem service research, involving the conceptualisation of externalities, methodologies for assessment of their (physical and economic) values and the cost of their provision, as well as the design of policy instruments that regulate their supply and demand. FES, like carbon sequestration and biodiversity, can be seen as public goods associated with forest management.[1] In this paper, we focus on the positive externalities associated with forestland use and notably address the impact of their provision on production costs. Ecosystem services (ES) provided by forests have become increasingly important in the recent forest economics literature as a result of the multifaceted relevance of forests to society, including their global contribution to climate change protection (Costanza et al., 1997; De Groot et al., 2002). The ecological and economic benefits of these services to society are often still undervalued and the methods for valuation are arguably limited and incomplete. Furthermore, this field is faced with problems of defining ecological functions and services, lack of reliable data, spatial aspects and multiple scales, all of which complicate the assessment. Moreover, the link between biological indicators and the costs of supplying ES is still unclear. This is why the development of approaches to the estimation of the marginal cost of ES provision is important. We show in this paper that the estimation of a cost function based on forest property data may be a powerful tool to analyse the structure of multi-output forest production and management.

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[1] In this paper, we use the terms ecosystem services, amenities, environmental services and externalities interchangeably.

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Abstract

Forest ecosystem service (FES) provisioning and management in Vietnam is a priority in the Vietnamese environmental agenda. The main rationale of private forest management is to maximise profits from timber and non-timber forest product (NTFP) production. From a social point of view there is an under-supply of positive forest externalities (or non-marketed ecosystem services). This paper therefore contributes to the ecosystem service (ES) literature by assessing the production cost structure, i.e., the cost of marketed production and provision of carbon and biodiversity, based on a survey of private forest owners in the Hoa Binh Province. The econometric analysis was carried out applying a dual cost function approach to analyse the trade-off between forestry costs and ecological performance. This is, to our knowledge, the first time such an approach has been applied to estimate the production relationship between marketed outputs and non-marketed ES in the forest sector. This approach appears to be appropriate for handling the multiple joint outputs of forest production. It allows us to estimate marginal costs and other cost measures such as cost complementarities in the production of multiple ES. Our results indicate that there is complementarity in the provision of timber and carbon sequestration and, consequently, policies that enhance carbon sequestration in private forests in Vietnam can be implemented without additional costs for the forest owner. We also found that keeping deadwood (favouring biodiversity) had no significant cost and was complementary with NTFP (also an indicator of biodiversity in our study), but could increase the marginal cost of producing timber. This means that biodiversity can be enhanced without additional costs on the condition that the quantity of deadwood does not increase too much.

Keywords: forest ecosystem services, trade-offs, marginal costs, translog cost function, cost complementarities, Vietnam

2.1 Introduction

Forest ecosystem services (FES) play an important role in forest management and ecosystem service research, involving the conceptualisation of externalities, methodologies for assessment of their (physical and economic) values and the cost of their provision, as well as the design of policy instruments that regulate their supply and demand. FES, like carbon sequestration and biodiversity, can be seen as public goods associated with forest management.[1] In this paper, we focus on the positive externalities associated with forestland use and notably address the impact of their provision on production costs. Ecosystem services (ES) provided by forests have become increasingly important in the recent forest economics literature as a result of the multifaceted relevance of forests to society, including their global contribution to climate change protection (Costanza et al., 1997; de Groot et al., 2002). The ecological and economic benefits of these services to society are often still undervalued and the methods for valuation are arguably limited and incomplete. Furthermore, this field is faced with problems of defining ecological functions and services, lack of reliable data, spatial aspects and multiple scales, all of which complicate the assessment. Moreover, the link between biological indicators and the costs of supplying ES is still unclear. This is why the development of approaches to the estimation of the marginal cost of ES provision is important. We show in this paper that the estimation of a cost function based on forest property data may be a powerful tool to analyse the structure of multi-output forest production and management.

Imperfect knowledge concerning the impact of forest management activities such as harvest strategies on ecosystems and service provision represents an important challenge for ecosystem management (Ninan and Inoue, 2013). However, it is important to understand the jointness in production, i.e., the interdependences in the provision of different ES from the same ecosystem when designing ecosystem management strategies and policies (Caparrós and Jacquemont, 2003; Boscolo and Vincent, 2003; Peerlings and Polman, 2004; Wossink and Swinton, 2007; Hodge, 2008; OECD, 2001; Ruijs et al., 2017). Knowledge of the cost structure offers the basis for setting efficient targets for provision of externalities and for cost-effective management strategies to meet such targets. Furthermore, the design of appropriate policy instruments, including market-based ones, relies on an understanding of the factors that have an impact on provision costs (Robert and Stenger, 2013). Nevertheless, very few empirical studies have investigated the cost of provision of FES as of this time.

1 In this paper, we use the terms ecosystem services, amenities, environmental services and externalities interchangeably.

However, one must be cautious when dealing with multi-output cost functions and production sets, together with "particular goods" such as ES. First, ES are the outputs of ecological production functions described by complex ecological processes with multiple interactions between ecological elements and human intervention, including, for example, timber harvest (Brown et al., 2011; Tschirhart, 2012). Examples can be found in species population dynamics in the standard predator–prey framework in which non-convexities appear in harvest production functions (Tschirhart, 2012). Furthermore, non-convexities in the production possibility set can arise from positive forest externalities along with a timber production function. Indeed, in the case where forest owners devote a part of their land to non-timber ES and the other part to timber production, this latter part also produces ES (e.g., water regulation, habitats). Hence, Brown et al. (2011) show that the production of ES over the total land could increase with an increase in land specialised in timber production. Secondly, as reported by Boscolo and Vincent (2003), fixed logging costs and administrative constraints on logging regulations can create non-convexities in production sets. In the case of road building, for example, high fixed costs exist, followed by increasing marginal costs, thus creating a non-convex forest production set. It has also been shown that administrative constraints can also create (even more) important non-convexities in the forest production set.[2] Recently, Ruijs et al., (2017) addressed these problems by presenting a method that does not require convexity assumptions. They estimate a transformation function with multiple ES by using a semi-parametric two-step approach that is flexible with regard to assumptions on the convexity of the production possibility set.

As highlighted by Fuss and Waverman (1981, p. 280), a dual cost function exists for every transformation function as long as the product transformation function satisfies normal regularity conditions such as convex isoquants. We thus based our cost function approach on the result of Briec et al., (2004) on non-convex technologies, revealing the existence of corresponding non-convex cost functions and establishing a local duality between non-convex technologies and cost functions. As a result, we chose a translog specification for the estimation of the cost function that is both flexible and has good local estimation properties since it is a second-order approximation, making the tests depend on the point of approximation.

In our empirical section, we use the cross-sectional data obtained from a survey of forest owners in Hoa Binh Province in Vietnam. Vietnam has undergone a transition from net

2 See Chavas (2009), who illustrates several cases of non-convexities of the production set when considering an ecological system as a production sub-system involving various private and environmental goods.

deforestation to net reforestation. In 1943, under the French colonial administration, the national forest cover was very low. After several decades of separation, the country was unified in 1975, but the forest cover decreased to 33.8% in 1976 (Lambini and Nguyen, 2014). This trend continued until 1990 when the forest cover reached its lowest level of 27.8% (Wil et al., 2006). During the period 1980–1995, Vietnam lost approximately 110,000 ha of natural forests annually (Nguyen et al. 2010). In addition to the loss in forest areas (deforestation), forest quality also decreased (forest degradation). The forest area with rich and medium timber stock had declined, whereas the area with poor stock (timber volume less than 80 m3/ha) had rapidly increased and reached 7 million ha in 1990. Due to the steep terrain in most forest areas and the concentration of rainfall in summer, poor forest sites were further degraded because of water and soil erosion (Vu et al., 2014).

FES provisioning and management in Vietnam is a priority in the Vietnamese environmental agenda. For example, several private afforestation programmes and programmes for the transition of forest ownership have been implemented. The Forest Protection and Development Plan for the period 2011-2020 includes targets on afforestation, regeneration and improvement of the quality of natural forests (FSDR, 2013). The main objective of the public forest programmes is to increase profits in timber and non-timber forest product (NTFP) production. However, at the same time, the supply of non-marketed FES is considered to be lower than the social optimum. Therefore, an assessment of the provision cost of FES (both marketed and non-marketed) provides relevant information for policy makers who design forest regulations and subsidy schemes.

In this article, we aim at modelling the production structure of FES by applying a dual cost function approach that appears to be appropriate for dealing with the multiple joint output production in forests. To do this, we quantify the cost of FES by estimating the marginal cost of service provision and assessing potential complementarity or competitiveness relationships between timber, NTFPs, the quantity of deadwood in the forests (taken as an indicator of biodiversity) and forest carbon storage.

This article seeks to fill several research gaps by: (1) contributing to the forest economics literature by assessing the production cost structure, i.e., the cost of marketed goods (timber, non-timber forest products) and non-marketed goods (biodiversity, carbon storage) with data from Hoa Binh Province in Vietnam; (2) developing and estimating a cost function where market and non-marketed goods are modelled as joint outputs; and (3) suggesting important policy implications for cost-efficient FES provision by accounting for cost synergies and competitiveness between these outputs. Although the cost function approach has been proven useful to analyse multiple output technologies and used in the analysis of joint production in agriculture (Nilsson, 2009; Gullstrand et al., 2014), this study is the first application of the analysis of joint production of market and non-market services in forestry.

The paper is organised as follows. After this introduction, Section 2 reviews the literature relevant to FES cost drivers and variables that influence the supply of multiple outputs. Section 3 focuses on the theoretical cost function framework relevant to the study. Section 4 presents and describes the empirical model specification for the cost estimation, introduces the study design and presents the data. Econometric results are presented in Section 5. Our findings are discussed in Section 6.

2.2 A brief review of the literature about the costs of ecosystem service provision

Assessments of the provision costs of FES have generally been based on the so-called engineering approach (Mäntymaa et al., 2014). In this case, provision costs are based on the opportunity cost of restrictions on timber production (Olschewski and Benítez, 2010; Ahtikoski et al., 2011).

Household models where forest management is integrated into the forest owners' consumption decisions have also addressed the production of amenity values (Newman and Wear, 1993; Pattanayak et al., 2002). However, these studies have focused on the impact of the household's amenity consumption on forest management decisions.

A relatively large forest economic literature that applies cost function models (Cubbage et al., 1989; Bauch et al., 2007) exists, but few of these models deal with the joint production of FES (Hof et al., 1985; Bowes and Krutilla, 1989; Misra and Kant, 2005). Hof et al., (1985) and Misra and Kant (2005) applied linear programming to estimate shadow prices of non-marketed output based on a cost minimisation model and output distance function, respectively. While econometric estimations of cost functions, which also include non-marketed goods and services, are non-existent in forestry, they have been applied in agriculture to analyse the joint production of milk, beef and biodiversity (Gullstrand et al., 2014) and the joint production of agricultural products and biodiversity (Nilsson 2009). One limitation of cost function estimation is the lack of adequate data, particularly difficult to gather in forestry because of the length of production processes and unequal operation costs over time (Petucco, 2014). Another limitation is related to outputs and the difficulty to use a "good" measure of ES. However, these limitations are also related to other empirical approaches to the analysis of joint production.

The costs of FES provision are affected by various factors. These factors include: firstly, the physical characteristics of the forest (soil quality, climate, slope, tree species, etc.); secondly, the spatial characteristics; and thirdly, the management characteristics of the forest owner. Concerning the physical characteristics, Wear (1994) reported that the physical description of the forest, i.e., forest type and age distribution, is important to include in the econometric estimation of production and cost functions. The size of the forest and its proximity to urban areas also influence the production structure. For example, Lien et al.,(2007) found that forest properties in a typically rural area had a higher efficiency level than those properties located close to urban areas. Naidoo and Ricketts (2006) emphasized that the significantly spatial heterogeneity in the provision of ES may be due to physical characteristics of the ecosystems such as slope and soil type. Ownership may also influence production efficiency. In a study of Polish forest districts, Siry and Newman (2001) found that privatisation of timber harvest may increase productivity, and Newman and Wear (1993) estimated restricted profit functions for Non-Industrial Private Forest Owners (NIPF) and industrial owners and found evidence that NIPF owners account for amenity values. Forest management plans are an important component of the administrative cost and could increase the forest owner's costs, even if the plan increases technical efficiency and, consequently, reduces long-term costs (Lien et al., 2007).

The characteristics of Non-Industrial Private Forest (NIPF) owners are a major consideration in the cost estimation since they are often key stakeholders in externality provisioning, and several studies have shown that forest owner or household characteristics may significantly impact management. In a study of Norwegian forest owners, Lien et al.,(2007) found that off-property wage income and income from on-property outfield activities such as recreational services and hunting lead to decreased technical efficiency, whereas properties that combine forestry and agriculture (i.e., properties where income from agriculture is high) have a higher level of technical efficiency in terms of timber harvesting. Characteristics of the owners, e.g., age and experience, have been shown to be significant determinants of efficiency (Carter and Cubbage, 1995, Lien et al., 2007). Misra and Kant (2005) include variables that describe knowledge and decision-making processes in joint forest management in Gujarat, India, applying an output distance function approach to explain provision costs.

The present study econometrically estimates a cost function to analyse the joint production of FES in private forests in Vietnam. As explained in the next section, this approach allows us to directly derive conclusions from the estimated model about the degree of complementarity between different FES.

2.3 Modelling cost of ES provision

A way to describe the joint production (or production "technology") is to use a cost function approach. As expressed by Fuss and Waverman (1981, p. 280), under assumptions of regularity of the product transformation function and the cost-minimising behaviour of firms, "the cost function is just as basic a description of the technology as the product transformation (joint production) function, and it contains all the required information, including information on jointness". This is due to the so-called principle of duality. Our objective is thus to estimate the costs that forest owners incur in providing FES as a function of outputs, input prices and fixed input variables.

However, one must be cautious when dealing with multi-output cost functions and production sets, together with "particular goods" such as ES. Because ES are the outputs of ecological production functions that describe a complex ecological process with multiple interactions between ecological elements and human intervention (Brown et al., 2011; Tschirhart, 2012), or because of the presence of fixed logging costs and administrative constraints on logging regulations (Boscolo and Vincent, 2003), non-convexities in production sets may arise. While cost functions for convex technologies are common knowledge, it is crucial to know that a dual characterisation exits for the case of non-convex production technologies. Although a duality result is hard to establish for a global cost function, this dual characterisation is, however, possible at the local level (Briec et al., 2004).

The forest is considered as a production process with several outputs where some may be positive externalities (biodiversity conservation, carbon sequestration). In other words, they are non-market goods or services and the owner is not remunerated for provision of these positive externalities. The provision of these different outputs (market and non-market goods and services) is typically considered as joint production that can also be observed in the literature on multifunctional agriculture (Lankoski and Ollikainen, 2003). The relationship between multiple outputs depends on the impact of several sources: technical interdependency in the production process, output produced from fixed non-allocable inputs, and outputs competing for an allocable input fixed at the farm level (Hodge, 2008; Shumway et al., 1984).

Several studies have recently considered joint production of market goods and amenities in agriculture (Peerlings and Polman, 2004; Nilsson, 2009; Gullstrand et al., 2014; Ruijs et al., 2015) and in agroforestry (Ofori-Bah and Asafu-Adjaye, 2011).

In this section, we show how production analysis can help us to estimate the cost of externality provision by the use of a cost function. A cost function describes the minimum costs of production for a given output. In other words, we assume that forest owners are cost-minimising. We apply a cost function approach since it has several advantages compared to a production function or profit function approach. First, it is quite straightforward to include more than one output and to derive cost elasticities and the marginal costs of a single output (Greene, 2008). A second advantage is that it can take the joint production relationship between marketed ES such as timber and non-marketed ES into account, in addition to different ES. It is relatively easy to perform a statistical test of whether services are competitive or complementary. Third, the estimation of a cost function is often more tractable and requires fewer hypotheses than the estimation of the profit function.[3]

A cost model for private forest owners

A forestland produces a vector of outputs $Y \geq 0$ (including harvested timber H and amenities A provided by the forest). The production process uses several variable inputs X and quasi-fixed inputs K (including forestland F and growing stock of trees S). We assume that forest owners have access to the same technology. Multi-input/multi-output combinations are site-specific. The site can be characterised by the physical environment (climate factors, soil characteristics that affect the uptake of inputs, and other abiotic factors in the soil and environment). The physical environment is difficult to manipulate on the short-term and affects production levels and multi-output combinations as well as the inputs required to carry them out. We denote this production environment by Z_t. The technology is thus described by the following multi-output transformation function:

$$T(Y_t, X_t, K_t, Z_t) = 0, \qquad \textbf{(1)}$$

where t is the time index. The dynamics of forest resources obeys the following equation:

[3] In the same way as for the duality principle between the cost function and a "well-behaved" transformation function, a similar relationship also exists between the cost and the profit functions. One piece of information specific to the profit function that cannot be provided by the cost function is the supply function that depends on the output price. However, we do not need to derive such a function for our analysis.

$$S_t = S_{t-1} + G(S_{t-1}) - H_{t-1}, \qquad \textbf{(2)}$$

where G is the natural growth function of the tree stock.

The minimisation of long-run costs (that takes inter-temporal decisions into account) leads to a long-run cost function that (perfectly) describes the multiple-output production. Given that we have only cross-sectional data for our empirical application, and consistent with Wear and Newman (1991) and Newman and Wear (1993), we simply consider a (restricted) short-run cost function.[4]

The short-run cost function can be derived from the minimisation of variable costs, represented here by the expenditures E incurred by the forest owner, conditional to the technology $T()$, fixed and quasi-fixed inputs K_t, and the production environment Z_t (we have dropped the index t for the purpose of clarity):

$$VC(Y, W.K, Z) = \min_{X \geq 0} \{E = W'X \mid T(Y, X; K, Z) = 0\}, \qquad \textbf{(3)}$$

where the vector of (positive) input prices is referred as to $W \gg 0$,[5] and T () is the set of technology used by the private forest owners. It is also assumed that the cost function is non-negative and non-decreasing in $Y \geq 0$ and $W \gg 0$. The cost function is also homogeneous, of degree one, concave and continuous with respect to W. We concentrate here on the conditional, variable cost function $VC(Y, W; K, Z)$.

The short-run cost function satisfies the same properties as the long-run cost function. However, it has to verify the additional property that it is non-increasing in K. Furthermore, fixed inputs do not necessarily achieve cost minimisation. Hence, the long-run total cost function can be recovered from the short-run cost function only if the latter is minimised with respect to K. Consequently, first-order conditions for long-run cost minimisation are satisfied if:

$$\frac{\partial VC(Y, W; K, Z)}{\partial K^*} = -w_K, \qquad \textbf{(4)}$$

4 This short-run cost function will be estimated without bias on the condition that we have sufficient information on the capital structure of the forest (e.g., size, age, composition).

5 W>>0 is a standard assumption, implying that prices W should not only be larger than 0 but should also not be close to zero. This is to avoid the problem of differentiating when prices approach zero.

where K^* is the optimal level of capital, and w_K its price. This condition can be used to test the good fit of forest capital to forest management. We can thus conclude that if this is not the case, i.e., if $\frac{\partial VC(Y,W;K,Z)}{\partial K^*} > -w_K$ or $\frac{\partial VC(Y,W;K,Z)}{\partial K^*} > 0$, then the forest management does not use all of the capacity available, e.g., forestland.

On the basis of the short-run cost function or the variable cost function, the marginal cost is given by $MC_y = \frac{\partial VC(Y,W;K,Z)}{\partial y}$, where y is an output belonging to Y. We can imagine differences in marginal costs according to different forest properties. Indeed, private forest owners' production of a non-optimal level of timber and, as a result, differences in efficiency between them may lead to differences in marginal costs. Moreover, the importance of asset fixity (or fixed factors and inputs) in the forestry sector implies that a forest area may represent a corner solution due to capacity restrictions, also implying that heterogeneous private forest owners produce goods or services with different marginal costs.

An important objective of our study is to assess cost complementarities and trade-offs between the provision of different FES. Cost savings may result from the production of several different outputs on one forest property rather than each being produced on different specialised properties. That is the definition of economies of scope that can be written as follows for two outputs (y_1, y_2): $VC(y_1, y_2, W; K, Z) < VC(y_1, 0, W; K, Z) + VC(0, y_2, W; K, Z)$. Empirically testing for the presence of economies of scope is not always so straightforward and depends on the functional form of the cost function as well. For instance, log-linear functions are problematic for evaluating costs with zero outputs. According to Panzar (1989), "it is useful to have available a condition defined in terms of properties of the multiproduct cost function that can be used to infer the presence of economies of scope."

The cost function, the estimated technological parameters and marginal costs make it possible to carry out a comprehensive analysis of the effect of output quantity levels (FES levels) on forest management costs. According to Panzar (1989) and Bowes and Krutilla (1989), for an application to multiple-use forestry, (weak) cost complementarities between two outputs y_i and y_j are defined as:

$$\frac{\partial^2 VC(Y,W;K,Z)}{\partial y_i \partial y_j} \leq 0. \tag{5}$$

Equation (5) implies that the marginal cost of producing y_i decreases with the increased production of y_j.Thus, this definition of cost complementarity will be used to investigate the concept of jointness in ES production, as in Gullstrand et al., (2014).[6] Note that competitive (or substitute) outputs are those for which the marginal cost of producing y_i increases with increased production of y_j. Independent outputs that characterise non-jointness in production are those for which the marginal cost of one output is unaffected by changes in the other one, at every output level (global condition).

2.4 Empirical application: Materials and methods

Econometric model: the translog cost function

The choice of the functional form to be used for estimating the cost function depends on several factors: data availability, assumptions about the forest owner's behaviour, and the purpose of the study. We can first consider the simple Cobb-Douglas parametric form for the conditional variable cost function depending on the variables defined in Equation (1): Y, W, K and Z:

$$\ln(VC) = \alpha_0 + \sum_i \alpha_i \ln(Y_i) + \sum_j \beta_j \ln(W_j) + \sum_k \gamma_k \ln(K_k) + \sum_l \delta_l Z_l \tag{6}$$

Even if this specification has the advantage of being expressed as a simple log-linear form, it is not flexible and considerably constrains the underlined technology. This is why we also consider the translog functional form (see Christensen et al., 1971, 1973), which is a second-order series Taylor approximation of the cost (in logs) with respect to explanatory variables (in logs). Its first advantage is that it imposes few restrictions *a priori* on the characteristics of the technology (such as convexity), so that it is considered as a flexible functional form. Moreover, ecosystem services (joint outputs) are complex due to their high non-linear relationships. Therefore, a non-linear specification of the cost function might have merit, raising the question of what type of non-linear representation of the cost equation might be appropriate. We thus base our functional choice of the cost function on the result of Briec et al., (2004) on non-convex technologies that shows the existence of corresponding non-convex cost functions and establishes a local duality between both non-convex technologies and cost functions. Hence, the translog specification is both flexible and has good local estimation properties, making the tests depend on the point of approximation. Finally, it permits the direct estimation of price

6 It is worth noting that, as demonstrated by Panzar (1989), "*a twice-differentiable multiproduct cost function that exhibits weak cost complementarities over the product set N, up to the output level y, exhibits economies of scope at y with respect to all partitions of N*".

elasticities as well as cost elasticities and, thus, economies of scale and other cost measures such as cost complementarities.

The econometric translog variable cost function is:

$$\ln(VC) = \alpha_0 + \sum_i \alpha_i \ln(Y_i) + \sum_j \beta_j \ln(W_j) + \sum_k \gamma_k \ln(K_k) + \sum_l \delta_l Z_l$$
$$+ \frac{1}{2}\sum_i \sum_{i'} \alpha_{ii'} \ln(Y_i)\ln(Y_{i'}) + \frac{1}{2}\sum_j \sum_{j'} \beta_{jj'} \ln(W_j)\ln(W_{j'})$$
$$+ \frac{1}{2}\sum_k \sum_{k'} \gamma_{kk'} \ln(K_k)\ln(K_{k'}) \qquad \textbf{(7)}$$
$$+ \sum_i \sum_j \delta_{ij} \ln(Y_i)\ln(W_j) + \sum_i \sum_k \eta_{ik} \ln(Y_i)\ln(K_k) + \sum_j \sum_k \theta_{jk} \ln(W_j)\ln(K_k) + \varepsilon_{n,}$$

with the error term $\varepsilon_n \sim iid(0, \sigma_v^2)$. The parameters to be estimated are: α_0, α_i, β_j, γ_k, δ_l, $\alpha_{ii'}$, $\beta_{jj'}$, $\gamma_{kk'}$, δ_{ij}, η_{ik}, θ_{jk}. This model can be estimated using classical econometric techniques such as the ordinary least squares method or the maximum likelihood estimation method (with the additional assumption of the normality distribution of errors).

We tested both Cobb-Douglas and translog specifications to find the functional form the most suited to our data. Moreover, the least parameter-consuming function (Cobb-Douglas) was used to test different specifications according to the cost variables.

Study design: Study sites and data collection

Vietnam has implemented large national reforestation and afforestation programmes over the past decades (Greening the Barren Hills Programmes, PAM programmes, Programme 327, the 5 Million Hectare Restoration Programme and the recent Plan 57 Programme. It is one of the first countries in Southeast Asia to have a national law on payment for environmental services (PES) in the forest sector and social forestry programmes are high on the government's agenda.

The study was conducted in the Hoa Binh Watershed in the North-Western Ecological Zone of Vietnam. The zone is characterised by the Da River upstream, a river valley and hilly terrain within the low land district valley. The two sampled study district sites in the catchment include Cao Phong (Binh Thanh village) and Dabac (Vay Nua village) located in the reservoir on the Da River, which is about 75 km west of Hanoi, Vietnam. The Da River flows from China via Vietnam to the East Sea. The length of the river in Vietnam is 493 km. The total surface area of the Da River Watershed is nearly 2.6 million ha and includes five provinces, namely Dien Bien, Lai Chau, Yen Bai, Son La and Hoa Binh. The climate of the sites is tropical monsoon with an average annual temperature from 22.5 to 23.2 ˚C. Annual precipitation ranges from 1300 to 2200 mm of which about 85% occurs from May to September. The topography is complex with elevations from 300 to more than 2000 m above sea level. Different land uses co-exist in the province. Grass and shrublands cover the largest share of the total land area, followed by forests that include both natural forests and plantations. Other land uses in the watershed include residential areas, water bodies, rocks, agricultural cropland, etc.

The social-ecological province of Hoa Binh is characterised by hills and mountains and is suitable for agro-forestry production by private owners. Households/owners in the study area have low net returns from crop production and agroforestry production. Small-scale forest management is therefore seen as an opportunity to increase household revenue by assessing their household opportunity cost. The households can gain additional benefits from REDD+ programmes in the region.

Data collection and survey protocol followed two approaches. The first component was to collect data on the cost of forest management and the socio-economic characteristics of the private forest owners in the selected districts of the watershed area. A questionnaire was designed and pre-tested with research assistants from the Vietnam Forestry University. A total of 180 private forest owners were interviewed individually. The survey was carried out based on recommendations from the Hoa Binh Provincial Forest Protection Department (PFPD) and the Da River Forest Protection Association. The sample was restricted to active private forest owners who own at least > 0.5 ha of forestland. The variables considered in this component included the physical features of the forest (forest size, age, origin, type), management characteristics (forest composition, management style, ownership objective, harvesting practices, decision making), spatial issues (plot number and size, continuous property, distance to forest), variable and fixed input costs to estimate the total cost included (cost of management/planting, seeds, fertilisers, thinning, harvesting, labour costs, administrative costs, land taxes, machines and equipment, etc.). Socio-economic and demographic data on the household included, among other things, ethnic group, marital status, household membership, sex, age, occupation and income sources. All of the respondents interviewed answered most of the questions of interest. However, in some rare cases, respondents did not have answers to some of the questions. These questions were therefore not analysed so as not to have any missing values in the sample analysed.

The other relevant data for the study were based on FES Output Assessment Indicators. These data are collected based on several years of ES quantifications by the Vietnam Forestry University (Pham, 2009, 2011; Nguyen et al., 2013) and in close partnership with the Hoa Binh Provincial Forest Protection Department (PFPD). The ES indicators considered for this study included NTFP diversity in the forest/ha, above- and below-ground carbon/tc/ha and quantity of deadwood/ha). These ES indicators were used as output variables in the cost model estimates.

Data

Data are described in Table 2.1. The cost variables are obtained from interviewed forest owners who reported the total direct costs associated with managing their forest. Two types of main costs were requested. The first ones concerned cost information on current management practices (referred to as $Curcost$), including the direct costs of planting, stand treatments, thinning, harvesting, transporting and road maintenance over the last five years. The cost estimate does not include land costs and opportunity costs of household labour. Instead, we included the variables $forha$ and *work*, representing forest size and hours that the household members spent working in the forest, respectively. The second type of information requested concerned added costs for biodiversity conservation and carbon sequestration (referred to as $Addcost$), related to actions to avoid clearcutting or even-aged timber harvesting, changes from exotic to native species, opportunity costs implied by the reduction of NTFP collection costs, and the restoration of barren lands, denuded hills and degraded natural forest areas. Total costs are the sum of these two types of costs and are referred to as $Totcost$.

The output variables considered include harvested timber volume, $timb,$ and the carbon stock (in standing timber and in soils), $carb$. The total carbon stock is a function of the above-ground biomass *(agb*) and below-ground biomass (*bgb*). The *agb* are estimated from the allometric equations (*ae*) that are developed based on the type of forest and management conditions, as proposed by Chave et al., (2005). The allometric equations include some measurable variables such as diameter at breast height (*dbh*), height (*h*) and wood density (*wd*). The below-ground biomass is estimated based on above-ground biomass using the linear function equation (Chave et al., 2005) with the root/shoot ratio. The total carbon stock is then calculated from *agb* and *bgb* using the default carbon fraction provided by the IPCC, from 0.47–0.50 (IPCC, 2006).

Table 2.1 Descriptive statistics (180 observations)

Variable	Definition	Mean	Std. Dev.	Min	Max
Curcost	Costs of current forest management (Dong/5 years)	9,460,294	6,447,055	2,400,000	53,032,700
Addcost (not directly used in the translog)	Additional cost of biodiversity conservation and carbon sequestration (Dong/5 years)	19,542,556	9,606,858	0	70,200,000
Totcost	Total costs (curcost + addcost) (Dong/5 years)	29,002,849	13,355,617	5,311,912	87,229,340
timb	Harvested timber volume (m3/year)	81.1	33.5	24	190
deadw	Number of dead trees	9.1	4.2	1	23
NTFP	Number of non-timber forest product species (total number of different NTFP species/ha/yr)	4.4	1.2	2	7
carb	Carbon stock on the forest property (tC/ha)	66.2	55.8	2.4	254.8
wage	Hired wage (Dong/Hlabour/forha/5 years)	752,158	949,822	144,761	9,850,550
work	Domestic work (hour/year)	1,021	856	30	3,024
forha	Forest size (ha)	7.5	3.4	1	16
forage	Forest age (year)	9.6	3.1	2	16
OtherObj (dummy)	=1 if forest ownership is for objectives other than forest investment or revenue	0.09	0.29	0	1
Type of forest					
Production (dummy)		0.43	0.50	0	1
Protected (dummy)		0.32	0.47	0	1
Special-use (dummy)	Cultural, historical and educational conserved forest sites	0.16	0.36	0	1
Other-type (dummy)		0.09	0.29	0	1
Forest composition management					
Evenaged (dummy)		0.24	0.43	0	1
Unevenaged (dummy)		0.38	0.49	0	1
Clearcut (dummy)		0.34	0.47	0	1
Others (dummy)		0.04	0.19	0	1

Two indicators of biodiversity as outputs are also included. The first is the number of different non-timber forest products harvested in the forest, $NTFP$, and the second is the number of dead trees in the forest, $deadw$.

The main variable input price is the labour price, i.e., the wage of hired labour ($wage$). We have no data on the growing stock of trees. However, different information can be used to describe the structure of the forest, such as the age of forest stands ($forage$), the type of forest (production, protected, special use), and the forest management composition (even-aged forest, uneven aged-forest, clear-cut). We also use a variable for forest ownership objectives that characterise objectives other than forest investment and revenue ($OtherObj$), such as emotional values (family heritage and connection to nature or ecosystem service conservation). Forest owners with these kinds of objectives represent only 9% of the sample, but could have an impact on the cost-minimising behaviour. For the econometric analysis, we used all 180 questionnaires.

2.5 Results

All variables (except the dummies) in the cost function are first logarithmically transformed and then mean-scaled. Therefore, the translog function can be considered as a local approximation around the sample mean. Hence, the estimated coefficients can be interpreted as elasticities at the sample mean values.[7] Moreover, all of the tests implemented will depend on the point of approximation.

Different estimated models are displayed. Estimation results from a Cobb-Douglas cost function specification are first presented in Table 2.2, and those from a translog specification are described in Table 2.3.

We first estimated two competitive Cobb-Douglas cost functions that differed with respect to the cost variables used as dependent variables. The first model used the current forest management costs ($Curcost$) and the second one ($Totcost$) summed current management costs and costs incurred for biodiversity conservation and carbon sequestration. The reason for testing the two models is that the question could arise as to whether costs associated with specific actions related to biodiversity conservation and carbon sequestration are an integral part of forest management.

[7] The computation of the cost elasticity from a simplified translog cost function estimated with only one variable Y, which is mean-scaled, is straightforward: $\ln(C) = \alpha_0 + \alpha_Y(\ln(Y) - \overline{\ln(Y)}) + \frac{1}{2}\alpha_{YY}(\ln(Y) - \overline{\ln(Y)})^2$. The cost elasticity with respect to Y is: $\frac{dC/C}{dY/Y} = \frac{d\ln(C)}{d\ln(Y)}$. This gives: $\frac{d\ln(C)}{d\ln(Y)} = \alpha_Y + \alpha_{YY}(\overline{\ln(Y)} - \overline{\ln(Y)}) = \alpha_Y$.

Table 2.2 Estimation results – Cobb-Douglas specification (180 observations)

	Model 1 (dep. variable: Curcost)		Model 2 (dep. variable: Totcost)	
Variable	**Estimate**	**Std. Err.**	**Estimate**	**Std. Err.**
constant	15.8650	0.0480***	17.0919	0.0466***
timb	0.1107	0.0727	0.4582	0.0706***
NTFP	0.3949	0.1138***	0.4268	0.1105***
deadw	0.1196	0.0788	0.0861	0.0765
carb	-0.0271	0.0438	-0.0153	0.0425
wage	0.4417	0.0421***	0.2459	0.0409***
work	-0.0083	0.0381	-0.1473	0.0370***
forha	0.0679	0.0705	0.0414	0.0685
forage	0.0700	0.0854	0.0151	0.0829
Other obj	0.1968	0.1033†	-0.0295	0.1003
(ref.: clearcut)	--	--	--	--
evenaged	-0.0052	0.0753	-0.1671	0.0731*
unevenaged	0.0153	0.0665	-0.0751	0.0646
(ref.: production)	--	--	--	--
Protected	0.0336	0.0693	0.0461	0.0671
Special use	-0.0391	0.0897	0.1440	0.0869†
Other type	0.1816	0.1099	0.1774	0.1065†
Adj. R^2	0.4735		0.4237	
AIC	180.35		168.83	
BIC	231.44		219.91	

Notes: †, *, **, and *** for significance levels of 10%, 5 %, 1% and 0.1%, respectively.

Model 1 and Model 2 show estimation results with all of the outputs (timber harvests, NTFP, deadwood and carbon), input price (wage) and capital variables (including domestic work, forest size and forest age). We increased this regression with binary variables that provided information about forest stand management (clear-cut, even-aged or uneven-aged), the type of forest (production, protected or for special use),[8] and a dummy variable characterising the objectives of forest ownership. This latter has a small but significant effect on the regression of current costs (Model 1) and none in Model 2. Moreover, based on a Likelihood Ratio (LR) test giving a statistic value of 12.112 and a p-value of 0.033, we concluded that forest type and forest stand management both have an impact on total costs (Model 2), whereas we found no significant effect on current costs (Model 1). Estimation results indicate that even-aged forests are significantly less costly than clear-cutting management and that production forests are less costly than all other types of forests (but the difference with

[8] Other variables describing the forest have been tested, including the origin of the forest (e.g., plantation, natural regeneration forest, agricultural land), but were found to have no impact on costs.

protected forests is not significant). Looking at the significance of variables, Model 2 seems to fit the data better than Model 1, but its adjusted R^2 is lower. To choose the best model, we used AIC and BIC criteria, which, with lower values, both made it possible to conclude in favour of Model 2. This indicates that our multi-output cost model that accounts for all forest management costs, including those for biodiversity and carbon production, is the best to describe the data. This may be not that surprising since Model 2 also includes costs directly related to the production of biodiversity and carbon storage that may depend on the explanatory variables related to the type of forest and the management objectives.

On the basis of the estimation results of Model 2, we found that timber and NTFP outputs have a significant (positive) impact on variable costs at the 0.1% level. In other words, the production of NTFP implies a cost for the owner. Their estimated coefficients show cost elasticities of output equal to 0.46 and 0.43, respectively. A cost elasticity of timber equal to 0.46 means that a 10% increase in timber harvesting leads to an increase in cost of only 4.6%. The same applies for the cost elasticity of NTFP. This means that there are specific economies of scale (computed as the inverse of cost elasticities and both found to be greater than 1) to be made in timber and NTFP production. However, we found no impact of deadwood and carbon production on variable costs. We also found that the wage variable is significantly positive at the 0.1% level, as expected. The coefficient associated with fixed domestic work is highly significantly negative. On the basis of Equation (4), this result does not allow us to reject the hypothesis of a good fit of domestic human capital with forest management. Finally, both proxy variables for the forest capital and its structure (size and age) were found to be non-significant in this cost function.

A second step in our empirical approach was to estimate the translog variable cost function.[9] Three nested and competitive specifications (Model 1 to 3) consisting of adding different sets of variables characterising the production environment (variables Z in Equations (1) and (3)) were tested. From the point of view of the significance of variables, the general fit of the models is good, even if only a few quadratic variables are significant. For this reason, we implemented an LR test that allowed a comparison between the translog cost function (see Table 2.3) and the Cobb-Douglas specification (see Table 2.2). Test results show that the translog is a better specification than the former, with a statistic value of 33.84 and a p-value of 0.0022. Furthermore, using the translog cost function specification as an alternative cost

9 In our study, there are no zero values for the output variables (potentially causing some problems with the log transformation), thus enhancing the appropriateness and robustness of the use of the translog multiple-output cost function.

benchmark provides more flexibility and better reflects the characteristics of the forest production. Finally, the adjusted R2 of the three models are good, ranging from 0.463 to 0.487.

Table 2.3 Estimation results – Translog specification (180 observations)

	Model 1		Model 2		Model 3	
Variable	**Estimate**	**Std. Err.**	**Estimate**	**Std. Err.**	**Estimate**	**Std. Err.**
constant	16.9639	0.0601***	17.0281	0.0663***	16.9845	0.0760
timb	0.3776	0.0779***	0.4059	0.0768***	0.3955	0.0788
NTFP	0.5389	0.1131***	0.5366	0.1108***	0.5022	0.1135
deadw	0.0697	0.0921	0.0704	0.0902	0.0676	0.0911
carb	-0.0283	0.0421	-0.0288	0.0415	-0.0330	0.0416
wage	0.2033	0.0453***	0.1888	0.0447***	0.1739	0.0454
work	-0.1251	0.0458**	-0.1480	0.0456**	-0.1325	0.0474
forha	0.1538	0.0840†	0.1558	0.0822†	0.1514	0.0823†
forage	0.0841	0.0892	0.0854	0.0873	0.0824	0.0876
timb*timb	-0.6535	0.2795*	-0.5421	0.2767†	-0.5075	0.2792†
NTFP* NTFP	1.9381	0.6051**	2.1383	0.5960***	2.2114	0.6068***
deadw*deadw	0.0542	0.1492	0.0731	0.1465	0.0724	0.1467
carb*carb	-0.0412	0.0581	-0.0080	0.0582	0.0089	0.0596
wage*wage	0.0683	0.0676	0.1021	0.0672	0.1060	0.0673
work*work	0.0624	0.0485	0.0421	0.0480	0.0560	0.0486
forha*forha	0.2507	0.1187*	0.2066	0.1178†	0.1783	0.1188
forage*forage	0.1082	0.2352	0.1443	0.2309	0.1223	0.2328
timb* NTFP	0.4272	0.3200	0.2253	0.3205	0.1821	0.3261
timb*deadw	0.2314	0.1558	0.2566	0.1530†	0.2214	0.1542
timb*carb	-0.0933	0.0746	-0.1228	0.0737†	-0.1252	0.0738†
NTFP *deadw	-0.6328	0.2964*	-0.6580	0.2904*	-0.6597	0.2918*
NTFP *carb	0.0295	0.1191	0.0106	0.1169	0.0051	0.1189
deadw*carb	0.0498	0.0704	0.0629	0.0694	0.0625	0.0695
(ref.: clearcut)						
evenaged			-0.2257	0.0756**	-0.2066	0.0764**
unevenaged			-0.0860	0.0626	-0.0787	0.0627
(ref.: production)						
Protected					-0.0136	0.0658
Special-use					0.0938	0.0869
Other-type					0.1450	0.1048
Adjusted R^2	0.463		0.4857		0.487	
AIC	163.19		157.09		159.10	
BIC	239.81		240.11		251.70	
LR test (CD vs. Translog)	33.84*** 0.0022)					
LR test (Forest composition)			10.08*** (0.0065)			

	Model 1		Model 2		Model 3	
Variable	**Estimate**	**Std. Err.**	**Estimate**	**Std. Err.**	**Estimate**	**Std. Err.**
LR test					3.99	
(Forest type)					(0.2626)	

NB: †, *, **, and *** for significance levels of 10%, 5%, 1% and 0.1%, respectively. P-values of tests in brackets.

We then used LR tests applying a backward strategy by testing if variables from a general model that included management and forest type variables could be removed without reducing the fit. Whereas variables used as proxies for management are found to have a significant impact on costs, the null hypothesis of joint nullity of coefficients associated with forest type variables cannot be rejected, so that Model 3 was found to be less good than Model 2. This implies that it is not the status of the forest that is important for the costs, but the applied management regime. AIC and BIC criteria confirm these results, with the lowest values for Model 2 (with very close BIC values for Models 1 and 2). Finally, we tested interaction terms with other variables (wage and capital variables), but none of the null hypotheses were rejected by LR tests.[10] These tests further confirm the robustness of our model estimates since it requires both the restricted and unrestricted estimates of parameters. Hence, the correct cost inferences on outputs can be carried out since our paper presents an estimated cost model that adequately and significantly fits the data. We will therefore only comment on the estimation results of Model 2.

Compared to estimates from a Cobb-Douglas specification, we found cost elasticities for timber and NTFP of less than 1 once again, indicating product-specific economies of scale. We now find a significant and positive coefficient associated with the size of forest property, representing the main capital input to the forest "technology". The cost elasticities with respect to capital are approximately 0.15. However, in Section 3, we saw that a test to check whether the forest owner's programme corresponds to a long-run cost minimisation would be a negative cost elasticity with respect to capital, $\frac{\partial VC(Y,W,K,Z)}{\partial K^*} < 0$ (see Equation (4) for the exact necessary condition). We may then conclude that as this is not the case, there is capital over-investment. In other words, the positive cost elasticity with respect to $forha$ associated with a timber cost elasticity of less than 1 suggests that forest properties at the sample mean are characterised by an excessive size of forest and that forest owners could harvest more over a long-term period.

[10] We implemented different LR tests where we crossed output with the other variables $\Omega = (W, K, Z)$ and tested the null hypothesis: $\Omega \times timb = \Omega \times NTFP = \Omega \times deadw = \Omega \times carb = 0$. All results are available from the authors upon request.

Moreover, if we had attempted to estimate a long-run cost function, as it is often advised for the forest sector, this function would have been mis-specified.[11]

Finally, it is interesting to comment on the signs of squared terms of timber and NTFP that give us an indication on the curvature of the incremental cost of each output. The incremental cost elasticity for timber decreases, as indicated by the negative sign of timb*timb (with a value of -0.05421 at a 10% level), implying that marginal costs of timber production decrease at the sample mean, which could be explained by the effectiveness of an additional hour of labour in harvesting more timber. Instead, the coefficient of NTFP*NTFP is strongly and very significantly positive (with a value of 2.1383 at a 1% level), implying increasing marginal costs at the sample mean.[12] However, we draw attention to the risk of a single-output view of marginal costs in a multiple-use framework. Indeed, an increase in an output can have an effect on the production of other outputs and their marginal costs. This is why we now analyse the relationships between different outputs through the measurements of jointness.

The cost of jointness

Focusing now on second-order (interaction) terms, we observe several interesting results. First, we found a negative coefficient of the squared term of $timb$, meaning that the marginal cost of timber harvesting decreases with increasing timber volume. Instead, the positive sign of the coefficient of the squared term of $NTFP$ indicates that its marginal cost of production increases with the number of non-timber forest products species found on one hectare of forest.

As reported in Section 3 and according to Panzar (1989), weak cost complementarities between two outputs y_i and y_j are defined as: $\frac{\partial^2 VC}{\partial y_i \partial y_j} \leq 0$. Fuss and Waverman (1981, p. 297) showed that the cross-partial derivative of variable costs given by Equation (5) can be rewritten in terms of log-transformed variables as follows:

$$\frac{\partial^2 VC}{\partial y_i \partial y_j} = \frac{VC}{y_i y_j}\left(\frac{\partial lnVC}{\partial lny_i}\frac{\partial lnVC}{\partial lny_j} + \frac{\partial^2 lnVC}{\partial lny_i \partial lny_j}\right) \quad \textbf{(8)}$$

---

11 This result differs from the one of Wear and Newman (1991) who found a restricted profit function to be convex in quasi-fixed inputs.

12 These measurements cannot be used as indicators of output-specific returns to scale. As stressed by Fuss and Waverman (1981, p. 282-283), “there exists no unambiguous measure of output-specific returns to scale except in the case of non-joint production”.

The first term $\frac{VC}{y_i y_j}$ being positive, the sign of the term between parentheses will give the nature of jointness of production.

On the basis of our translog specification (6), $\frac{\partial lnVC}{\partial lny_i}\frac{\partial lnVC}{\partial lny_j} + \frac{\partial^2 lnVC}{\partial lny_i \partial lny_j} = \alpha_i\alpha_j + \alpha_{ij}$ (at the sample mean). We can note that the condition of non-jointness is $\alpha_i\alpha_j + \alpha_{ij} = 0$. This means that a test that does not reject the null hypothesis will allow us to conclude the non-jointness of outputs. A significant negative sign means output complementarity, whereas a significant positive sign means competitive outputs. The results are displayed in Table 2.4.

Table 2.4 Jointness in FES production

			Confidence interval	
	Estimate	Standard error	2.5%	97.5%
timb*NTFP	0.4431	0.3286	-0.2010	1.0872
timb*deadw	0.2852*	0.1543	-0.0171	0.5876
timb*carb	-0.1345*	0.0778	-0.2869	0.0179
NTFP*deadw	-0.6202**	0.2937	-1.1958	-0.0447
NTFP*carb	-0.0048	0.1193	-0.2387	0.2290
deadw*carb	0.0608	0.0691	-0.0745	0.1962

Notes: Estimates based on the coefficients of Model 2 in Table 2.3.
Standard errors are computed with the delta method.
*** Significant at 1%, ** at 5%, * at 10%.

We found three significant relationships between outputs. The coefficients of timb*carb and NTFP*deadw are significantly negative (with the values -0.1345 and -0.6202, respectively). These results show that the marginal cost of timber harvesting decreases when the amount of carbon sequestration increases (complementarity between timber and carbon), suggesting that timber production and carbon sequestration policies can be implemented as part of a (diversified) multi-functional forest. Similarly, the marginal cost of NTFP decreases with respect to the amount of deadwood, also implying cost complementarity. The significant positive value of the coefficient associated with timb*deadw (0.2852) shows competitiveness between timber production and the presence of deadwood. This result seems to indicate that a specialisation both in timber production and in biodiversity conservation would lead to efficiency gains. However, we should be cautious about any policy implementation based on this result because it holds at the approximation point (at the sample mean) and the coefficient is only significant at the 10% level, but also because we did not find a similar result for our other indicator of biodiversity, NTFP.

It is also interesting to observe that we found no significant effect between carbon sequestration and NTFP and deadwood (both indicators of biodiversity in our paper). This basically implies that increasing the carbon sequestration will not have an effect on the marginal cost of NTFP production and leaving deadwood in the forest. In other words, this signifies that increasing the carbon sequestration will not incur additional costs on forest owners and is neither in competition nor complementary with biodiversity (as measured by our indicators).

2.6 Discussion

In recent years, questions concerning PES in Vietnam have arisen (To et al., 2012; Suhardiman et al., 2013) since the country has implemented several ES policies and market institutions that enhance the commoditisation and exchange of FES. However, it is preferable to know the structure of the production and costs of multiple FES beforehand, whereas empirical case studies often still focus on the complementarities and competitiveness in the supply of FES. Our discussion highlights these limitations. Private forests in the Hoa Binh Province provide multiple FES. These include, among others, timber and non-timber products, carbon sequestration and biodiversity. We show that by using forest property data from a face-to-face survey and a cost function approach, it is possible to obtain relevant insights into the cost structure of the provision of multiple outputs in private forests in Vietnam.

Our results indicate that carbon sequestration in the forest is a complementary output of timber harvesting. This shows that production-oriented forests may not have a negative impact on carbon storage. We also found that the cost of keeping more deadwood was not significant but that keeping deadwood had a negative effect on the marginal cost of NTFP and a positive effect on the marginal cost of producing timber. It can be imagined that keeping some deadwood would have no significant cost since some wood is damaged during harvest and therefore has no value. However, if a larger amount of timber is kept, this means that valuable timber is kept as well and may therefore represent a significant cost. These results are in agreement with those derived from the theoretical model of Boscolo and Vincent (2003) indicating that whereas uniform management appears to be preferable in the case of the carbon–timber production set, the relative advantage of the two specialised types of managements is less clear for the biodiversity–timber production set.

Other recent studies show different results such as those of Vangansbeke et al., (2017) who use spatial analyses and find trade-offs between biodiversity conservation and both wood production and recreation, even if they use innovative forest management planning to make it possible to combine biodiversity conservation, with a restricted impact on both services. Caparrós and Jacquemont (2003) show that creating economic incentives for carbon sequestration may have negative impacts on biodiversity, especially for afforestation and reforestation programmes (e.g., if pre-existing land uses had high biodiversity values). In agriculture, Ruijs et al., (2017) report that there are diseconomies of scope between agricultural revenues and the other considered ES (biodiversity, carbon, recreation). Moreover, biodiversity and carbon sequestration exhibit both economies and diseconomies of scope, but many areas have characteristics that suggest high opportunity costs, thus making it costly to increase both simultaneously.

One of the limits of the present study is the rather coarse proxies used to represent the growing timber stock in the forests (forest age and size). While forest management is a long-term investment and represents a dynamic optimisation problem where the standing stock is an important variable that influences decisions and costs, the stand age is not directly correlated with standing stock. This may also explain why the forest age variable (forage) was not statistically significant. We compared different specifications of the cost functions, i.e., Cobb-Douglas and translog specifications, as well as different assumptions about fixed costs and other potential determinants of the cost structure. This also allows us to assess the robustness of our results. A common result, independent of the model used, was that the cost elasticity was significantly positive for timber and non-timber outputs, while carbon storage and deadwood had no impact on cost in any of the five models estimated.

We can conclude that policies that enhance carbon storage can be implemented without additional costs for the forest owner. However, it should be noted that our results only apply within the range of carbon sequestration experienced today by forest owners. More drastic policies that imply huge increases in carbon storage will probably imply new management practices that are not observed today among forest owners. Such policies cannot be evaluated based on our results. Indeed, as highlighted by Tschirhart (2012), in economics, convexity is convenient because efficient allocation mechanisms are obtainable using a price system. However, when production sets are non-convex, as is likely in the context of FES, economic tools (such as taxes, subsidies or PES) might produce non-optimal results since models show the possibilities of multi-equilibria or even optima that are minimum (Brown et al., 2011).

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Chapter 3

Paper 2: A Comparative Analysis of the Effects of Institutional Property Rights on Forest Livelihoods and Forest Conditions: Evidence from Ghana and Vietnam

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A comparative analysis of the effects of institutional property rights on forest livelihoods and forest conditions: Evidence from Ghana and Vietnam

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Vietnam

ABSTRACT

Effective institutional property rights are increasingly becoming an important part in the allocation of scarce forest resources and to combat the "tragedy of the commons" thesis. Our paper outlines conceptual, analytical and theoretical aspects of forest institutional property rights and an empirical synthesis of main findings from institutional property rights effectiveness in a cross-country comparative context. The paper employs property rights based framework coupled with some New Institutional Economics (NIE) debates as a diagnostic framework for understanding forest property rights. The Sustainable Livelihoods Framework (SLF) provides empirically insights into how "forest institutional property rights" impact on forest communities' livelihoods and management. Our analysis provides support for the argument that forest institutional property rights play important role in the livelihoods of forest dependent communities and in forest management, but that can be context specific as showcased in our findings. Finally, the paper makes some recommendations in institutional analysis of forest property rights, such as strong and clearly defined property rights, integration of formal and informal rights and suggests strong linkage between institutional property rights and sustainable livelihoods as a "panacea" for sustainable forest livelihoods and management in developing countries.

1. Introduction

Forest degradation, deforestation and forest resource depletion have been the focus of environmental concerns for years, especially in developing countries (FAO, 2010; Ribot, 1998; Agrawal and Gibson, 1999). In the last few decades the concepts of "forest institutional property rights" and "sustainable forest management" are key issues in international forest discourse and these impact on national forest policies in developing countries. Effective and robust forest institutional property rights are increasingly becoming an important part on the allocation of scarce forest resources and a solution to the "tragedy of the commons" (Ostrom, 2005; Delacote, 2012). Global forestry is characterised by several institutions concerning climate change adaptation and mitigation and provisioning of forest ecosystem services (Bose et al., 2012). However, most forest institutional property rights have failed to work effectively in developing countries (Humphreys, 2011). Some of these failures are related to the multi-actor dimension nature in the forest sector, power levels in global negotiations and interests from developed economies due to neo-liberal principles of capitalism, free trade and high cost of policy implementations among many others (Dimitrov, 2005). Few studies address the quality of forest institutional property rights in developing countries and their impact on households' livelihoods and forest conditions in a comparative approach (Coleman and Fleischman, 2012; Cronkleton et al., 2012; Larson and Dahal, 2012). Obviously, such analyses are increasingly needed in the context of integration and globalisation.

Our study applies an institutional economic analysis to develop an analytical model based on institutional property rights and sustainable livelihood framework for forest management scenarios in Ghana and Vietnam. The choice of Ghana is based on the following factors: (1) the country is often cited as a model of functional institutions in West Africa (Teye, 2013); (2) the forest sector contributes immensely to the Gross Domestic Products (GDP); (3) a biodiversity hotspot of West Africa (FAO, 2010). Vietnam equally offers a good setting for the study since (1) the country is in economic and forest transitions, hence interesting to assess their forest institutional property rights; (2) Vietnam is a good global example for rapid afforestation, reforestation, practice of sustainable biodiversity, soil and water protection, and increasing participatory governance (FAO, 2010). The main motivation of this study is our need to understand the role of institutions, property rights on livelihoods in a forestry context and examine the connectivity of these three concepts. This need has a theoretical offset hence our attempt to operationalise using a broad framework for conceptualisation. This is addressed by answering the following explicit three questions: (1) what is the "state of the art" literature on institutional property rights in resource management? This helps in the decomposition of property rights linkages on livelihoods and forest conditions; (2) how to comparatively evaluate these property rights effects on livelihoods and forest conditions as outcomes in an empirical micro level?; and (3) how to integrate these findings into building models for sustainable future design of forest institutional property rights arrangements? These questions will contribute to

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Abstract

Effective institutional property rights are increasingly becoming an important part in the allocation of scarce forest resources and to combat the "tragedy of the commons" thesis. Our paper outlines conceptual, analytical and theoretical aspects of forest institutional property rights and an empirical synthesis of main findings from institutional property rights effectiveness in a cross-country comparative context. The paper employs property rights based framework coupled with some New Institutional Economics (NIE) debates as a diagnostic framework for understanding forest property rights. The Sustainable Livelihoods Framework (SLF) provides empirically insights into how "forest institutional property rights" impact on forest communities' livelihoods and management. Our analysis provides support for the argument that forest institutional property rights play important role in the livelihoods of forest dependent communities and in forest management, but that can be context specific as showcased in our findings. Finally, the paper makes some recommendations in institutional analysis of forest property rights, such as strong and clearly defined property rights, integration of formal and informal rights and suggests strong linkage between institutional property rights and sustainable livelihoods as a "panacea" for sustainable forest livelihoods and management in developing countries.

Keywords: Institutions, Property Rights, Livelihoods, Forest Conditions, Ghana, Vietnam

3.1 Introduction

Forest degradation, deforestation and forest resource depletion have been the focus of environmental concerns for years, especially in developing countries (FAO, 2010; Ribot, 1998; Agrawal and Gibson, 1999). In the last few decades the concept of “forest institutional property rights” and “sustainable forest management” are key issues in international forest discourse and these impact on national forest policies in developing countries (Ostrom, 1990). Effective and robust forest institutional property rights are increasingly becoming an important part on the allocation of scarce forest resources and a solution to the “tragedy of the commons” (Ostrom et al., 2005; Delacote, 2012). Global forestry is characterised by several institutions concerning climate change adaptation and mitigation and provisioning of forest ecosystem services (Bose et al., 2012). However, most forest institutional property rights have failed to work effectively in developing countries (Humphreys, 2011). Some of these failures are related to the multi-actor dimension nature in the forest sector, power levels in global negotiations and interests from developed economies due to neo-liberal principles of capitalism, free trade and high cost of policy implementations among many others (Dimitrov, 2005). Few studies address the quality of forest institutional property rights in developing countries and their impact on households’ livelihoods and forest change in a comparative approach (Yami, 2009; Eric, 2012; Cronkleton et al., 2012; Larson et al., 2012). Obviously, such analyses are increasingly needed in the context of integration and globalisation.

Our study applies an institutional economic analysis to develop an analytical model based on institutional property rights and sustainable livelihoods framework for forest management in Ghana and Vietnam. The choice of Ghana is based on the following factors: (1) the country is often cited as a model of functional institutions in West Africa (Teye, 2012); (2) the forest sector contributes immensely to the Gross Domestic Products (GDP); (3) a biodiversity hotspot of West Africa (FAO, 2010). Vietnam equally offers a good setting for the study since (1) the country is in economic and forest transitions, hence interesting to assess their forest institutional property rights; (2) Vietnam is a good global example for rapid afforestation, reforestation, practice of sustainable biodiversity, soil and water protection, and increasing participatory governance (FAO, 2010). The main motivation of this study is our need to understand the role of institutions, property rights on livelihoods in a forestry context and examine the connectivity of these three concepts. This need has a theoretical offset hence our attempt to operationalise using a broad of frameworks for conceptualisation. This is addressed by answering the following explicit three questions: (1) what is the "state of the art" literature on institutional property rights in resource management? This helps in the decomposition of property rights linkages on livelihoods and forest ecosystem services management ; (2) how to comparatively evaluate these property rights effects on livelihoods and forest ecosystem services management as outcomes in an empirical micro level? ; and (3) how to integrate these findings into building models for sustainable future design of forest institutional property rights arrangements? These questions will contribute to existing empirical knowledge gaps on forest institutional property rights in developing economies and offer some recommendations for a strong, robust and result oriented institutional property rights that take into account livelihoods of the people, communities and forest resource sustainability. The general hypothesis of our study is "*robust and strong forest institutional property rights incentivise sustainable livelihoods at a micro level"*.

The paper employs Property Rights (PR) based framework coupled with some New Institutional Economics (NIE) debates on institutional property rights and applies them to the Sustainable Livelihoods Framework (SLF) to explain empirically how forest institutional property rights in these two countries impact on forest communities' livelihoods and forest conditions. Our paper unravels and sheds some lights on research gaps on forest institutional property rights and their linkages to sustainable livelihoods outcomes which are key to sustainable forest resource management. The paper contributes to empirically testing the problems of forest property management and institutional arrangements outcomes. The study provides empirical findings to earlier developed property rights analytical frameworks (Demsetz, 1967; Schlager and Ostrom, 1992; Ostrom, 1990; Hagedorn, 2008). It also makes a contribution by reviewing two property rights outcomes (negative and positive institutional property rights outcomes). Finally, the comparative assessment of forest institutional property rights with two or more countries are relatively rare and dated, hence our comparative exercise in this paper provides some contributions to the usual country specific studies in the property rights literatures.

The paper is organised into 5 sections, after this introductory section, section 2 focuses on theoretical institutional debates relevant to evaluate institutional property rights linkages to sustainable livelihoods and forest resource management. Section 3 reviews the empirical literature based on evaluation of forest institutional property rights and their effects to unravel research gaps in the literature. Section 4 compares forest institutional property rights in the two case studies. Section 5 concludes by summarising key issues for institutional analysis of property rights in forest communities and suggests policies for sustainable forest ecosystem services management.

3.2 Theoretical Background

The theoretical background for our analysis consists of several arguments on institutional property rights literatures based on New Institutional Economics (NIE) debates and Sustainable Livelihoods Framework for impact analysis. The background for our analysis comes from the following three theoretical discussions (1) New Institutional Economics (NIE) theories of institutions (Coase, 1960; Williamson, 1994; North, 1990, 1997; Ostrom, 1990, 2005), (2) Property Right theories (Demsetz, 1967; North, 1990; Schlager and Ostrom, 1992), and (3) Sustainable Livelihoods Framework (Chambers and Conway, 1992; Scoones, 1998; DfID, 1999). This is to allow pluralistic methodologies since institutions function in various interfaces. It should be noted that, despite an impressive growth in these theories and empirical findings, the dynamics of institutions, property rights allocation and outcomes remain highly disputed, terminological problems and historical inconsistencies still exist in the debates.

3.2.1 New Institutional Economics (NIE)

Neoclassical economic models are very important for the analysis of market systems, NIE extends these models by examining how property rights emerge and control externalities (North, 1990, 1997) and how transaction costs influence institutional arrangements and economic behaviour and outcomes within society (Coase, 1960; Williamson, 1994). It does this by building on, modifying and extending neoclassical theories. NIE attempts to relate theory of institutions and economic systems. They argue that the performance of a market economy depends on institutions. NIE builds on choice theoretic approach based on orthodox assumptions of scarcity and competition. They are interested in social, economic and political rights that govern everyday life. In studying institutions and their interactions, NIE integrate mental and cognition models to explain reality which shapes institutional environment built (North, 1990, 1997). This field does not abandon completely core neoclassical theory but rejects the neoclassical assumptions of individual perfect information; unbounded rationality and zero transaction cost (Coase, 1960; Williamson, 1994). One intriguing question that economists try to answer is how institutional property rights emerge, i.e. either through self organisations (Ostrom, 1994, 2005) or through a central authoritative agent (Bromley, 2008). Most New Institutional Economists tend to concord with the evolutionary rationalism hypothesis that institutional structures develop spontaneously (Williamson, 1994). Demsetz (1967) views institutional change in response to grassroots demand at the time when demand exceeds associated cost to allocate resource efficiently. Existing power structures matter, institutional change will be costly and not necessarily optimal at the supply side (North, 1990, 1997). New institutionalists argue that humans create institutions as a result of high risks and transactions cost. Two inter-connected theoretical concepts that NIE examines and that are relevant for our comparative empirical work are further reviewed. These are (1) theories of institutions and (2) property right based framework.

3.2.2 Theories of institutions

NIE is often criticising neoclassical models from an institutional perspective. This is based on the fact that they fail to explain the nature of institutions and their roles in economic activities. In New Institutional models, institutions are broadly defined as means to reduce transaction and information costs based on choice theoretical approach (North, 1997; Coase, 1960). Institutions coordinate economic activities from formal and informal means. According to Coase theorem, institutions could lower transaction cost through coordination of actions and gains.

Institutional theories deal with the assessments of institutional functions, and focuses on how individuals and groups behave and act in relation to rules and how they construct new institutions (North, 1990; Williamson, 1994). Institutions are conceptualised as rules of the game that influence change in a social context. Eggertsson (1996) classifies institutional analysis into 3 levels. First and second levels of analysis are grouped into institutions and economic performance with influence from institutional environment and contractual arrangements. The third level deals with mixed elements of institutional frameworks and structure of property rights. North (1990) also categorises institutions into formal and informal rules and even further to Institutional Environment (IE) and Institutional Arrangements (IA) which composes of rules and organisations, respectively. Williamson (1994) equates right institution to property right and provides a contractual composition to institutions. Institutions help to understand how society functions and governs. Institutions are normally featured with positive externalities; however, they could be some institutional “spillovers” as negative externalities. Ostrom (1990) proposes eight design principles, positing them to characterise robust institutions for managing common-pool resources. These principles contribute to understanding the free rider problem, even without a state or formal rules.

3.2.3 Property Rights Theory

Property Rights (PR) are very fundamental to NIE discourse and they have attempted to elaborate more on the concept over the past years. Much work focussed on differences between property rights systems as alternative ownership arrangement (private versus collective). A large body of literature emphases the role of property rights in economic activities (Coase, 1960; North, 1990). Coase (1960) emphasises that transactions involve the exchange of property rights rather than just goods and services. A simplistic reading of Coase theorem could lead to the conclusion that allocation of property rights is immaterial for economic efficiency, since a Coasean bargain would correct such misallocation. NIE provides both theoretical and empirical evidence that initial property rights allocations matter in economic activity. Property rights function as a guiding incentive to internalise externalities. These rights are defined as the exclusive rights over a resource or over the attributes of a resource and emerge when it becomes economic for those affected by externalities (Demsetz, 1967; Eggertsson, 1996). These definitions offered by NIE are often criticised since they reduce ownership arrangement based on person to thing relations.

One relevant issue of property rights debates is how they evolve. The emergence of property rights is in response to conflict over resource use claims. Property rights emerge historically when resources are congested and vulnerable to the tragedy of the commons (Demsetz, 1967; North, 1990). Feeny et al (1990) define four basic property right regimes: (1) open access, (2) communal property, (3) private property, and (4) state property. Different property rights exist, i.e. individual, common and public. These rights must be separated from the resources (Ostrom, 2005). Absence of property rights leads to resource depletion hence users of resources would organise themselves and create rules that specify property rights (Ostrom, 2005). The bundles of rights framework instead of a single right is applied for this study (Schlager and Ostrom, 1992).This framework distinguishes property rights theories with diverse bundles of rights and posed the possibility that one can relate the different ways that these bundles are combined to a set of positions that individuals hold in regard to operational settings. In this framework, they reviewed 5 types of rights to resources, which are normally followed by responsibilities: (1) access right to a physical location; (2) withdrawal right; (3) management right - the regulation of uses by others , and to improve or change the system by improvements; (4) exclusion right - to exclude others from access or withdrawal, and (5) alienation right - to alienate (sell, lease, or give away or leave to a designated heir) the rights held. These rights may or may not be transferable. They named 5 “positions” which a right holder may occupy: (1) authorized viewer with access but not authority to harvest or make important changes; (2) authorized user, with right to access and withdrawal, carefully described in some norm or formalization usually; (3) “claimant” with access, withdrawal, and management rights. This position improves long term investment security and acquires returns on improvement; the distinction is in a more individualized claim rather than a group claim. (4) “proprietor” with rights to access, withdrawal, management, and long-term security of expectations. This holder usually has obligations to regulate use, invest, and determine access. Finally, (5), “owner” with all the rights including rights to alienate the resource.

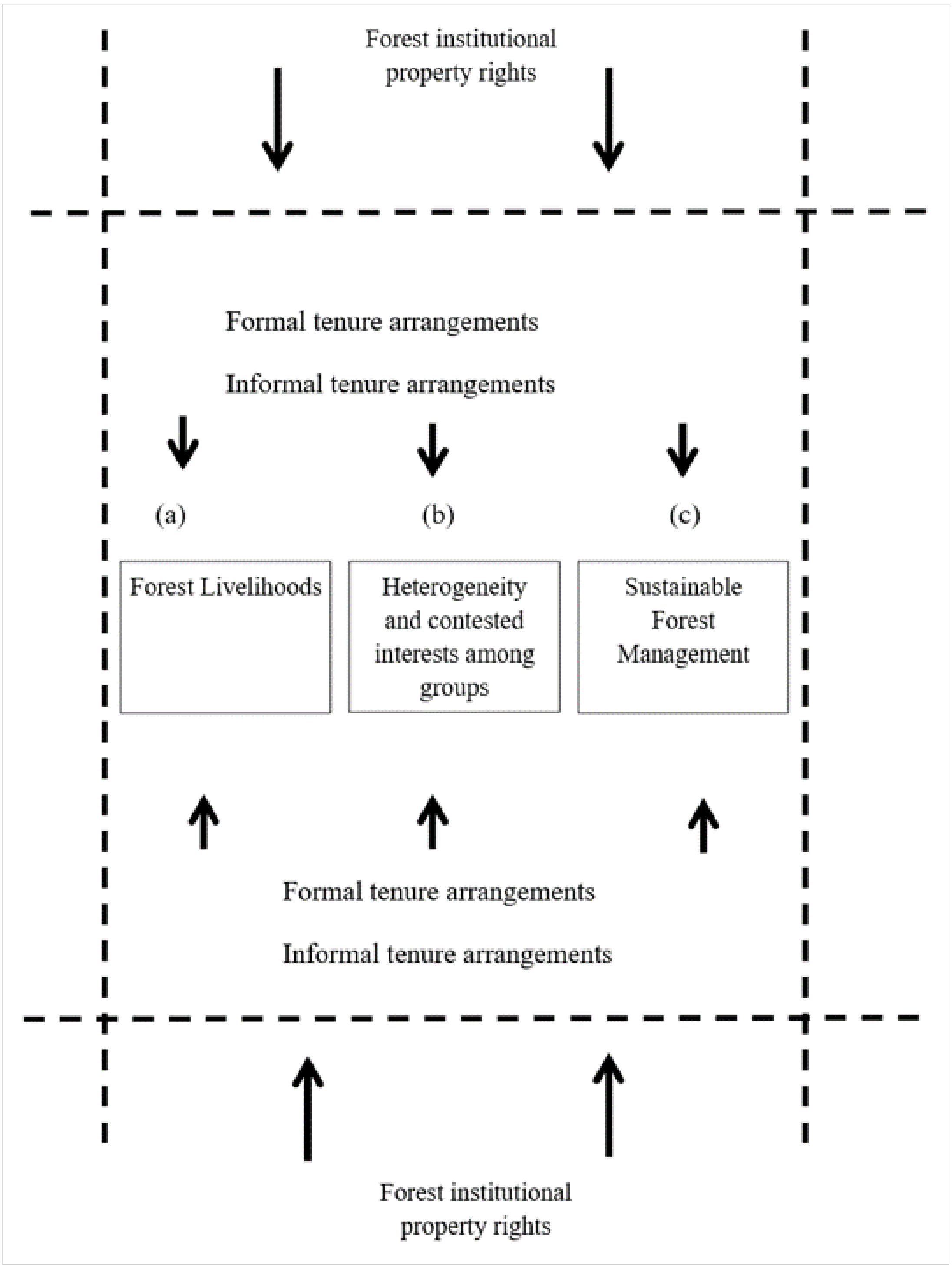

Figure 3.1 A diagrammatic representation of forest institutional property rights

Source: Modified based on North, 1990; Schlager and Ostrom, 1992; Bromley, 1989

The diagrammatic representation in Figure 3.1 depicts forest institutional property rights into two tenure arrangements, (1) formal and (2) informal. Institutional property rights are translated into formal and informal tenure arrangements as indicated by the arrows (legal arrangement and local norms and traditional arrangement respectively). These rights have 3 impacts as shown in the 3 panels, panel (a) represents impacts on forest sustainable livelihoods (elaborated in Figure 3.2), and panel (b) conveys issues of heterogeneity and contested interests in forest tenure arrangements. The middle structural component of panel (b) differentiates heterogeneous actors involved in these arrangements and the differences that influence their actions and activities. Panel c represents institutional property rights impact on sustainable forest conditions.

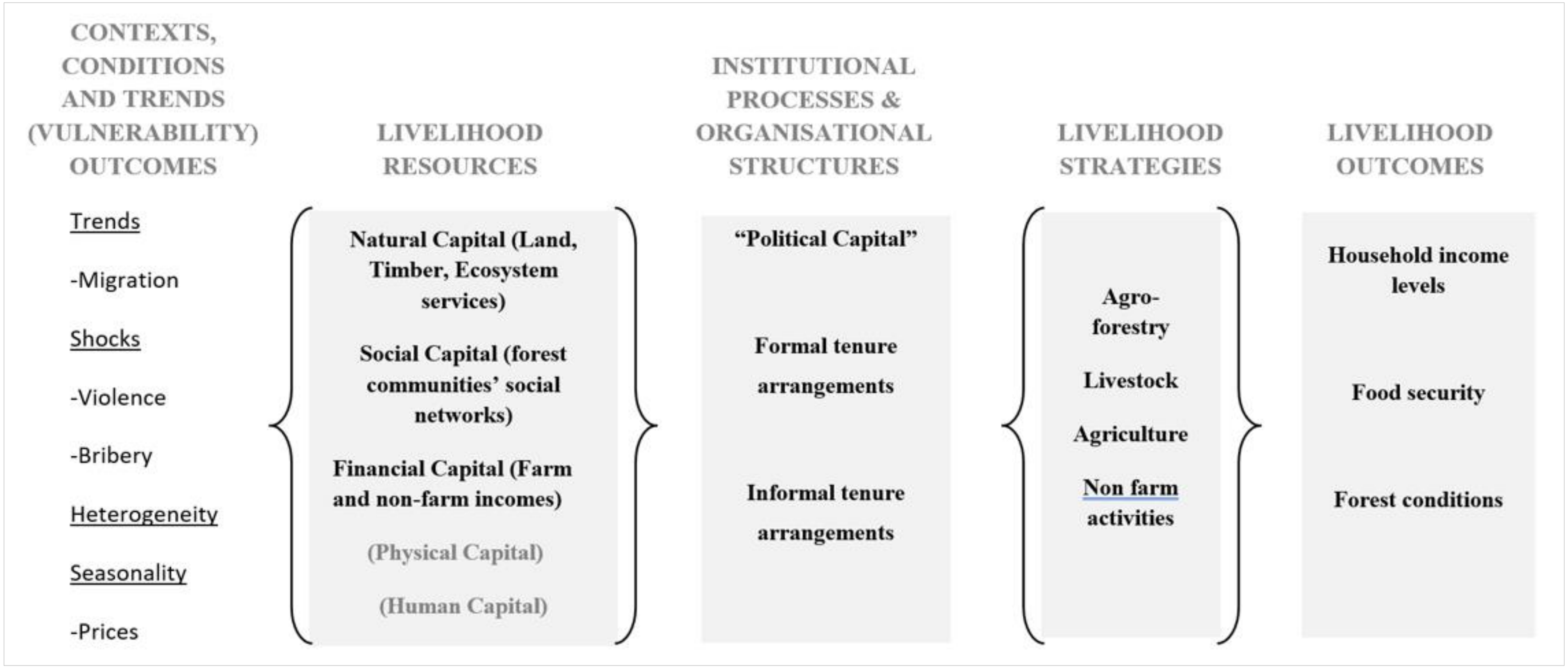

Figure 3.2 **Conceptual framework for the livelihood analysis**

Source: Adapted from Scoones, 1998; DfID, 1999; Ostrom, 2005; North, 1997

3.2.4 Sustainable Livelihoods Framework (SLF): Institutional Property Rights Context

The concept of Sustainable Livelihoods (SL) is an attempt to expand the conventional definition and approaches to poverty reduction. The idea was first introduced by the Brundtland Commission on Environment and Development, and the 1992 United Nations Conference on Environment and Development expanded the concept, advocating the achievement of sustainable livelihoods as abroad goal for poverty eradication. The Sustainable Livelihoods Framework (SLF) was developed by the Department for International Development (DfID) and associated often with the work of Ashley et al. (1999) and of the Overseas Development Institute (ODI). The SLF was adapted for our study for three reasons: (1) it is holistic and centers on people and community livelihoods, (2) it offers a great chance to analyse institutional designs and livelihoods to address sustainability issues, and (3) it could empirically demonstrate and evaluate institutional property rights linkages with livelihoods and forest conditions as outcomes. The framework defines livelihood as the capabilities, assets and activities required for a means of living; and is sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, provide opportunities for the next generation; and contribute net benefits to other livelihoods at the local and global levels in the short and long-term (Chambers and Conway, 1992). To comprehend the complexities and differentiated processes through which livelihoods are constructed, Scoones (1998) analyses the institutional processes and organisational structures that link these various elements together. He defined "institutions" as "…regularized practices (or patterns of behaviour) structured by rules and norms of society which have persistent and widespread use". These rules and norms enable or act as a barrier to achieving livelihoods outcomes and are linked to the five capital assets (natural, social, financial, physical and human) in the framework. Baumann (2000) particularly adds a new dimension of 'political resources' in the concept which hitherto was not taken into account. The framework conveys 5 important themes that run through the analysis, namely (1) *the vulnerability context*, (2) *livelihood asset*, (3) *institutional processes and organisational structure*, (4) *livelihood strategies, and* (5) *livelihood outcomes* (See Figure 3.2).

The institutional processes in this framework fit very well in our analysis of forest institutional property rights analysis since they incorporate institutions (legal laws and legislations and informal norms) that shape livelihoods outcomes in communities. The processes can significantly facilitate or hamper the development of livelihoods strategies and access. The framework peruses that institutions influence access to livelihood resources which are closely linked to institutional outcomes (Ostrom, 1990, 2005; North, 1990). The institutional process and structures are central and important as they operate at all levels and effectively determine access, terms of exchange between different types of capital, and return to any given livelihoods strategy. This could explain the call for an "institutional capital" (political) by some authors in the SLF (Shankland, 2000). They suggest that SL framework should be modified to include "political capital", because unequal power relations have influences over livelihood processes of the poor. This part of the framework could be described as the most important and relevant aspects since both formal and informal institutions have effects on livelihoods outcomes.

3.2.5 Forest Institutional Property Rights Sustainability

Following the discussions on the theoretical models applied to this paper, we construct a set of systems through a Venn diagram to demonstrate the linkages and how we could achieve forest institutional property rights sustainability. The conceptual background for our analysis consists of the three theories discussed above and connects each of these theories in different sets and their relationships in detail in the Venn diagram below (Figure 3.3).

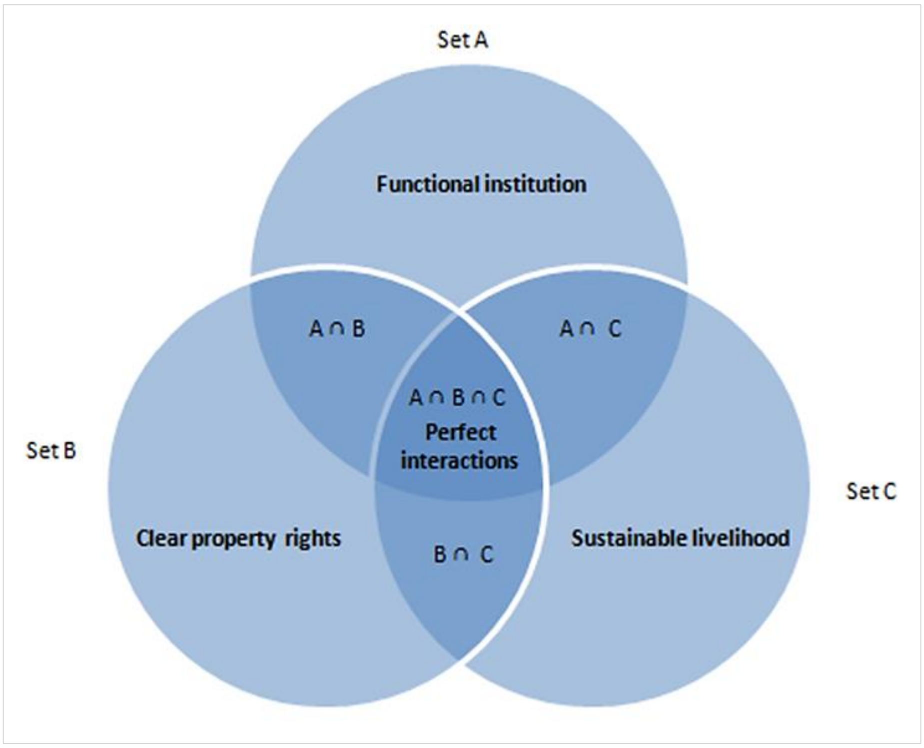

Figure 3.3 A conceptual Venn diagram linking the various theoretical concepts discussed in the paper

The diagram was developed based on the original theories discussed in: (1) New Institutional Economics (Coase, 1960; North, 1990, 1997), (2) Property Right theories (North, 1990; Ostrom, 2005; Bromley, 2008), and (3) Sustainable Livelihoods Framework (Chambers and Conway, 1992; Scoones, 1998; DfID, 1999).

In Figure 3.3, functional institutions are represented by set A and composed of efficient and effective formal and informal rules that deal with property rights (North, 1990). Institutions in this framework are separated from property rights, even though in an empirical case, the two are closely related and the former defines the latter. However, our Venn diagramme separates clearly defined property rights from institutions as shown in set B to elaborate the importance of property rights and also to decompose the concept further in a forestry setting. Set C deals with sustainable livelihood outcomes based on functional institutions and clear property rights in set A and B. Subset A∩B shows interactions between functional institutions and clear property rights, subset B∩C demonstrates clear property rights and sustainable livelihood, subset A∩C features a functional institution and sustainable livelihood. In this figure, we prove that there is a potential interdependence and complex interaction of the 3 different sets and subsets (A, B, C, A∩B, B∩C, A∩C, and A∩B∩C) as a system. Their connectivity could be directed or undirected and can modify their linkages and performances. At the core of this diagramme is a “perfect” interaction of all 3 sets, A∩B∩C, demonstrating the interactions of all sets and exhibits effective interactions of a sustainable institution that promotes an efficient and effective “functional institution-clearly defined property right-sustainable livelihood outcome” scenario. We propose in our diagramme an integrated system of all sets since they are constantly interacting as connected components.

3.3 Empirical Literature Review on ForestInstitutional Property Rights

There is a considerable empirical literature that postulates the role of institutional property rights in resource management in developing countries. There are, however, relatively few recent empirical studies that analyse this subject from a comparative perspective and in a livelihood and sustainable management of forest resources context (Larson et al., 2012; Cronkleton et al., 2012; Eric, 2012). The emphasis of the review is based on 2 considerations, namely relationship between forest institutional property rights: (1) livelihoods, and (2) sustainable forest conditions. Key selected literature in the empirical review are summarised in Table 3.1.

Table 3.1 Some selected publications for the empirical review

Author	Issues	Studied Site
Yami et al., 2009	Informal and formal institutions, common pool resources, livelihoods	Sub-Saharan Africa
Larson et al., 2012	Commons management, implementing forest tenure reforms, forest livelihoods	Asia, Africa, Latin America
Sikor et al., 2011	Open access, forest conflicts, illegal logging, corruption	Vietnam
Marfo et al., 2012	Community tenure rights, forest governance, benefit sharing, REDD+	Ghana
Nguyen et al., 2010	Forest privatization, land reforms, incentives, household livelihoods	Vietnam
Eric et al., 2011	Forest decentralization, local forest investment, livelihoods.	Bolivia, Uganda, Mexico, Kenya
Teye, 2012	Forest Property rights, Forest governance, integrated policy network	Ghana
Ganga et al., 2011	Forest tenure, drivers of tenure, challenges and opportunities	Asia

This section begins by empirically decomposing forest institutional property rights and their effects; next we construct a problem tree of forest institutional property rights, then we conclude with some debates on forest there rights. Recent empirical assessments that have attempted to define and test institutional property rights in the forest context, include the works of Yami et al. (2009) who review the strengths of institutions in sustainable Common Pool Resources (CPRs) management in Sub-Saharan Africa and conditions that influence their effectiveness. The comparative work of Larson et al. (2012) reviews on the extend of change in rights and ownership patterns in communities using the bundle of rights concept and case studies from Latin America, Asia and Africa. They identify a clear rise in policies granting new property rights to local forest communities. Cronkleton et al. (2012) draws on a global comparative study of forest tenure reforms and the challenges in implementing these reforms. Eric (2012) estimates the effects of forest decentralisation on local forest investments, rulemaking, wealth inequality, and forest conditions in Bolivia, Mexico, Kenya and Uganda.

For easy empirical analyses, forest institutional property rights are defined as all formal and informal rules in a forest context and covers institutional environment and arrangements in a given context. These rights can be affected by external factors such as non forest related rules. Empirical aspects of forest institutional property rights include forest rules (formal and informal tenure arrangements, governance of forest benefits), forest policies (forest administration, timber prices, participation, incentive schemes) and forest sustainability (forest fringe communities' livelihoods, net forest area change and forest ecosystem services).

3.3.1 Forest Institutional Property Rights Problems

We analysed the challenges and problems in the forest sector from an institutional diagnosis and identify institutional property rights inefficacies in a developing country context by taking account of causes and effects scenarios. The problem tree review is based on physical, economic, formal and informal policy levels as challenges and problems in the forest sector. Physical levels (forest ecosystem lost, land degradation, etc.), economic levels (timber, household livelihood, social cost, etc.) and policy levels (conflicting property rights, non-participation of forest communities, accountability, etc.) are analysed as causes and effects of institutional problems in the forestry sector. Figure 3.4 on institutional property rights “problem tree” analysis is based on the empirical literature reviews and gives background information on the causes and effects of their rights.

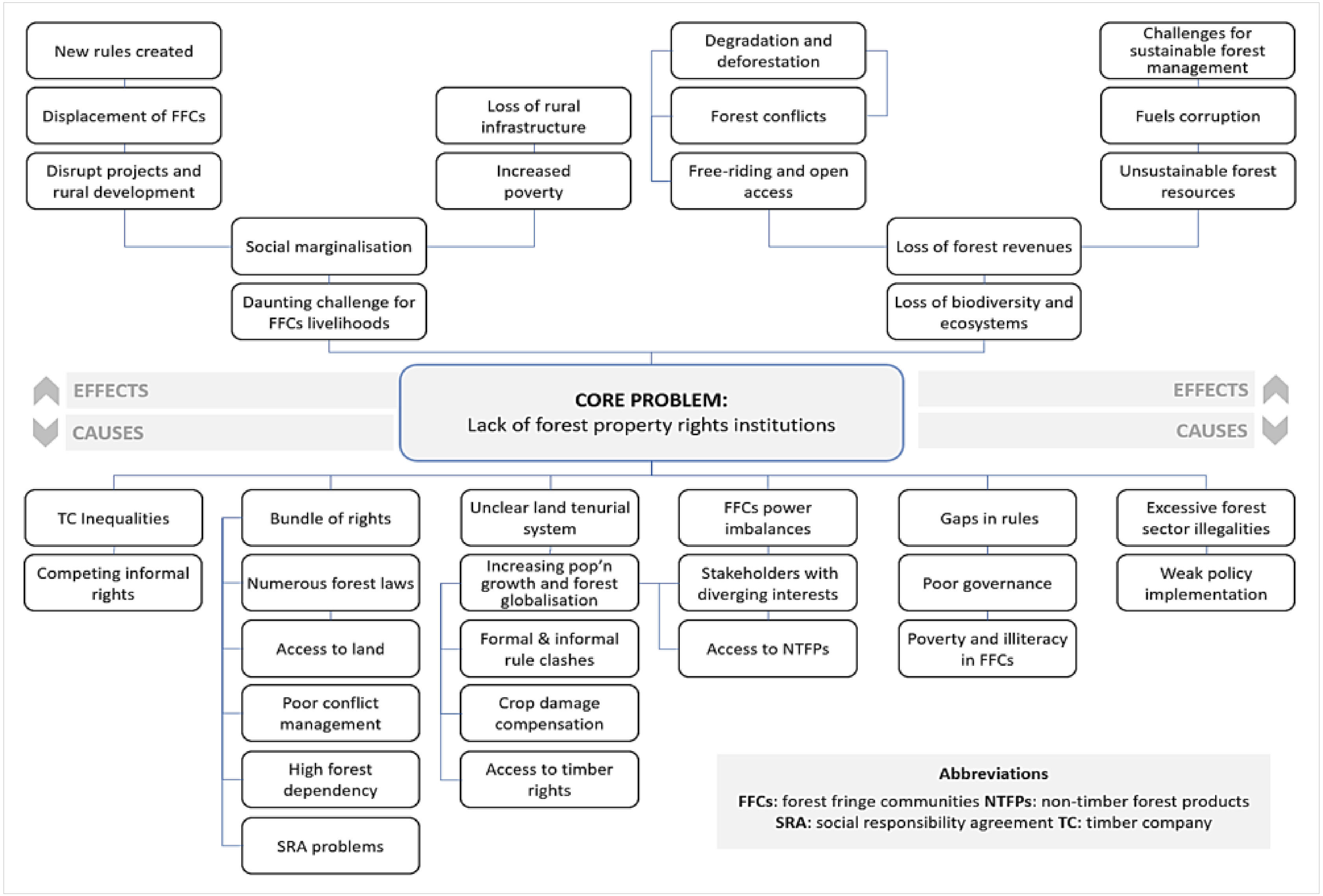

Figure 3.4 Forest institutional property rights problem tree analysis

3.3.2 Forest Institutional Property RightsDebate: Negativism and Positivism Metaphors

It is increasingly clear that, there are relatively few papers that look at forest institutional property rights linkages on livelihoods and forest ecosystem services sustainability and from a national level using empirical findings (Kofi, 2004; Marfo et al., 2009; Nguyen, 2006; Nguyen et al., 2010; Sikor and To, 2011; Hansen et al., 2009). Recent studies have identified conflicting role of institutions in resource management in developing countries. There are different explanatory frameworks established to explain the relationships of formal and informal institutions in sustainable forest management and further evaluate the impact of institutional change on rural livelihoods and forest degradation and deforestation (Richards et al., 2003). These institutions and governance structures make varying assumptions about their outcomes.

There are two clear debates on institutional outcomes in the literature. The first school of thought “Institutional Positivists” assumes that forest institutional property rights have positive role in forest poverty reduction and forest ecosystem services management (Hough, 2003) and that institutional change and innovations could enhance economic growth (Ruttan et al., 1984). The second school of thought “Institutional Negativists” challenge the first school and claim institutions bring nothing new to forest management in developing countries but rather complicate the already existing forest management scenarios and conditions (Richards et al., 2003; Colchester, 2006; Sikor and To, 2011).

The “Institutional Positivists” debate that institutions are crafted to bring positive incentives and internalise externalities. Several forestry research and scholarships with focus on institutions have normally connected institutionalisation of property rights as a relevant instrument for sustainable forest management and governance (Hough, 2003; Dimitrov, 2005). Pagdee et al.,(2006) give a broad conclusion that institutional arrangements are significantly associated with sustainable forest management, hence supporting the positive hypothesis. Recent findings from Sunderlin et al., (2008) and Ganga et al,. (2011) compare land tenure security strong role in the structure of incentives that motivate the protection and destruction of forest resources and further elaborate the role of the informal customary tenure systems at the local level could equally enhance resource protection and sustainability.

Though this school of thought is the most accepted one in the forest property rights literatures, and described very well in theory and in practice, there are still some authors who argue on institutional property rights failures in the forest sector and their negative externalities in developing country context. This leads us to a second school, the so called "Institutional Negativists". They claim that forest institutions serve as a disincentive for individuals and society at large and contribute nothing to sustainable livelihoods and forest ecosystem services management. The protagonists of this school further argue that formal institutions are too complex and inappropriate hence lead to forest ecosystem services degradation and increased deforestation. Colchester (2006) blames formal institutions such as inappropriate forest laws as the cause of forest criminalities. Campbell et al., (2001) indicate that informal institutions in Zimbabwe have created numerous forest management challenges. In line with this, the breakdown of informal institutions and their failure to comply with the principle of exclusivity resulted in an increased level of degradation and loss of forest ecosystem services at several places in Africa (Masangano et al., 2003). Larson et al., (2012) affirms to this school of thought and concludes that clear institutional property rights alone is not sufficient conditions for achieving sustainable forest ecological conditions, livelihoods and equity and calls for the need to critically review other exogenous factors. Bao (2006) criticises the successful results from Vietnam's forest allocation programme and affirms that the results are mixed successes as a result of the unequal distribution of rights and negative impacts on poor household livelihoods.

The above review differentiates the two schools in approach, objective and methodology in looking at forest institutional property rights outcomes. They compare the differences between institutional property rights emphasising the liberating and or efficiency enhancing role of forest these rights and those emphasising oppressive tendencies and outcomes. Nevertheless, these distinctions are more dependent on power relations-what rights are favoured and for what purposes and not on the role of the rights themselves.

3.4 Comparative Institutional Analysis of Forest Property Rights in Ghana and Vietnam

3.4.1 Background Data: Ghana and Vietnam

Ghana's land size is about 24 million ha. The High Forest Zone (HFZ) constitutes about 8 million ha. The tropical forest zone is characterised into reserve forests (production and protected) and off reserve forests. About 53% of the permanent forest estate is outside timber production cycle (Agyarko, 2007). Ghana's forest forms part of the biodiversity hotspots of West Africa and the high zone forest contains over 70% of floral diversity (Wagner et al., 2008). The area of natural forest cover consists of dense forest of 1,193, 000 ha and mosaic forest and crop lands composed of 6,525, 000 ha.

Forest sector contributed about 7.2 % to GDP in 2010. The sector contributes about 11% of total export earnings and is the 4th foreign exchange earner in the country. An estimated 70% of rural communities depend on the sector for livelihoods. However, about 80% of national forest lost was estimated in the period between 1955-1972 (Kotey et al., 1998) and 16% of natural forest lost. Annual rate of deforestation in Ghana is 2.1 % as a result of cocoa farming intensification, illegal logging, biomass burning and forest conflicts (FAO, 2010) to a total forest area of 4,940,000 ha between 2000-2010 thus accounting for about 21.7% of all Ghana's land. The Country's forest is constantly disappearing and relatively faster in Africa. With the current rate of deforestation of about 65,000 ha per annum, this rate comes with ecological and economic consequences.The sector accounts for about 63% of cost of environmental degradation of natural resources (World Bank, 2006).

Globally, there is a flourishing forest plantation development by engaging the private sector through the allocation of land for forest plantation in developing countries. Ghana government launched the National Forest Plantation Development Programme (NFPDP) in 2001 to enhance the rapid loss of forest resources. In 2002, forest plantation was recorded at 76,000 ha, about 1.2 % of the area of national forest cover and 0.3% of total land area (FAO, 2010).

The 1994 Forest and Wildlife Policy provided a good strategic framework for actions within the forestry sector, enhanced conservation and redefined property rights allowing for minimal participation of local people. The policy for example influenced the Modified Taugyya Systems (MTS), Government Plantation Development (GPDP), Commercial Plantation Development (CPD) and the Timber tree planting by small-scale growers (OFTP) in on and off reserves. From 2000-2010, there have been about 140,886 ha engaging about 124,912 individuals in these plantation schemes (Thomas et al., 2012). These arrangements have had several effects on forest livelihoods and forest ecosystem services management.

Vietnam on the other hand is located in the Indochina peninsula of Southeast Asia and has a tropical forest as well. Three quarters of the land have mountainous and hilly terrain. Forest land is estimated to be about 13,797,000 ha representing about 44% of the country's land. Forested land constitutes natural and plantation forests, and categorized normally into production, protection and special-use forests for planning.

The country had a forest cover decrease from 43% in 1943 to approximately10-20% in 1990. At present however, the country's annual forest net gain rate is about 1.08% making it a global top 10 with the largest net gain in forest area. Vietnam was the largest tropical country exporter in 2007 with a peak of $3.7 billion in 2010 (ITTO, 2011). Forest plantation in Vietnam has increased and in 2010 reaching an annual rate of 2.1%. Table 3.2 provides a background data on Vietnam's forest area, cover and annual change from 1943 to 2010.

Table 3.2 Forest change in Vietnam (1943 - 2010)

	Forest area (1,000 ha)					Average annual change	
Year	Natural forest	Plantation	Total	Forest cover (%)	Forest area per capita (ha)	Area (1,000ha)	%
1943	14,300	0	14,300	43.0	0.70		
1976	11,077	92	11,169	33.8	0.22	-94.88	-0.66
1980	10,186	422	10,608	32.1	0.19	-140.25	-1.26
1985	9,038	584	9,892	30.1	0.16	-143.20	-1.35
1990	8,430	745	9,175	27.8	0.14	-143.40	-1.45
1995	8,252	1,050	9,302	28.2	0.12	25.40	0.28
2000	9,444	1,471	10,915	33.2	0.14	322.60	3.47
2005	10,283	2,334	12,617	36.4	0.15	340.40	3.12
2010	10,305	3,083	13,388	39.5	0.15	154.20	1.22

Sources: Wil et al., 2006; Nguyen et al., 2010

From the above table, Vietnam's forest sector has seen a constant growth in both forest plantation and natural forest, most particularly from the year 2000. This constant increase is as a result of clear definition of tenure arrangements and increased household privatisation in the sector.

3.4.2 Data collection and research approach

In order to review and understand institutional property rights processes and their linkages to household livelihoods and forest conditions, it was necessary to adopt a case study field analysis. The methodological approach used in this study was a comparative case study approach. The study identified criteria for analyses as "cases". These criteria were (i) forest property rights, (ii) effect of these rights on livelihoods, and (iii) forest conditions. We applied this approach to Vietnam and Ghana. According to Gerring (2007), using few countries could provide us more detailed findings by comparing the similarities and differences of forest property rights, livelihoods and forest conditions. Data collection for the study is based on literature review and field works.

The Ghana's empirical case study was based on collection of qualitative and quantitative secondary data and grew literature on forest institutions, property rights and forest-based livelihood themes. There was a systematic review of the collected literature based on relevant research questions framed. To supplement the systematic review, the Ghanaian case study applied a semi-structured questionnaire in some randomly sampled 50 households in seven communities in Ahafo AnoSouth, Forest District of the Ashanti Region. All selected communities were located in the so called ‘off-reserve areas’ hence not protected reserve. The district is scarcely populated by forest–dwelling people with variable degree of cocoa farming and ‘hunter-gatherer’ type of economic activity. The field survey had the following three objectives (1) to understand the dynamics of property rights ownership, (2) to identify the framework of benefits sharing arrangements among traditional authorities and communities and (3) to assess forest livelihoods and conditions. We also applied some participatory rural appraisal tools (field observations, transect walks and focus group discussions) to collect primary data from the field. Several key informant interviews were conducted with traditional authorities, timber companies and the Forest Services Division (FSD) on forest property rights (state, private, communal) and forest based livelihoods.

In the Vietnam’s empirical case, we used parts of the findings of the already published work of Nguyen et al., (2010). Their study examined the impact of tenure rights by comparing the situation before and after land privatization in 1993. Data from 1993, 1998, and 2006 were used. Data in 1993 and 1998 were collected by Vietnam Central Planning Committee and General Statistics Office (GSO) in the two Vietnam Living Standard Surveys (VLSSs) supported by the World Bank. The aim of these VLSSs was to provide a systematic collection of data reflecting household livelihoods standards and to provide necessary information to meet the needs for analysis of socio-economic policies. The survey sample was selected to be representative for the whole country. The selection of the sample followed a method of stratified random sampling (*See* GSO, 2000 for more details). Their study re-interviewed the households which had been surveyed by the two VLSSs in five communes in the Northern Uplands with a total number of 160 households in 2006. The household questionnaire was adjusted in accordance with the following information: household general information, forest property rights, afforestation; employment including non-farm activities, income and expenditure, borrowing, lending, and saving. Screening the data after the survey indicated 133 households with sufficient and reliable data in all three years suitable for the analysis, making a panel dataset of 399 observations.

3.4.3 Results and discussion

This section starts with a comparative descriptive statistics and narrow down to both countries on the quality of property rights, livelihoods and forest conditions and finally concludes with a comparative analysis of effects of attributes of these rights on forest livelihoods and forest conditions.

Table 3.3 shows key variables of both countries in terms of forest data, forest management conditions, international engagements, and social forestry and forest livelihoods. Comparatively, we see clear evidence of forest management conditions in these case studies. Ghana's rate of change of forest trends/deforestation is very high representing a deficit of -2.19 % and Vietnam rather has an annual forest net gain rate of about 1.08 %. This shows that forest cover in Vietnam is more favourable compared to Ghana which has a deforestation deficit. They witness a high forest growing stock of primary and planted forests than Ghana and a shift from net deforestation to net reforestation-forest transition. A reason for this trend is Vietnam's devolution policies, particularly strong led government forest devolution efforts and political will. Vietnam's turning point began with her lead in redefining forest institutional property rights as well as a strict and comprehensive reforestation policy. These efforts gave private forest owners the capacity and incentive to invest in long-term forest projects. Moreover, Vietnam's forest ecosystem services sustainability indicators (biodiversity, soil and water conservation) globally are higher and better than Ghana. Social forestry and forest based livelihoods in Vietnam are equally better than Ghana from our review. Ghana, however, has a higher governance structure than Vietnam, but this status is not reflected in her forest sector since there are still numerous governance challenges in the forest sector. Ghana's governance in this context is associated with democracy and Vietnam's medium governance status could be as a result of her authoritarian centralistic political history and socialist system of governance.

Table 3.3 Key descriptive statistics of Vietnam and Ghana forests

Variables	Ghana	Vietnam
Rural population (%)	50	72
Total land area (000ha)	22, 754	31, 008
Total forest area (000ha)	4,940	13, 797
Total forest to land area (%)	22	44
Annual change rate of forest trends/deforestation rate (%)	-2.19	1.08
Primary forest area (%)	8	1
Planted forest area (000ha)	260	3, 512
Production forest (%)	23	47
Forest for protection of soil and water (%)	7	37
Biodiversity conservation (%)	1	16
National biodiversity index	0.646	0.682
Forest growing stock (000m3)	291, 000	870,000
Forest devolution, local participation and clearer forest reforms	Medium	High
ODA disbursement for the forest sector (million $)	12.21	24.15
Engagement in REDD+ initiatives	High but medium low capacity of technical readiness	High and high capacity of technical readiness
FLEGT VPA Timeline	Ratified (3rd phase)	Formal negotiations (2nd phase)
Governance	High	Medium
Social Forestry	Medium	High
Forest Based Livelihoods	Not improved	Improved

Source: FAOSTAT Forestry database 2010; OECD Statistics Database 2012

3.4.3.1 Forest institutions

There are several formal and informal rules that govern forest management practices. In Ghana, there are a lot of informal rules that govern tenure arrangement, which we categorise into access-based rules (some days of the week e.g., Fridays and Sundays are observed as holidays and no access or activity in the forest), benefit-oriented rules (traditional chiefs control benefits from the forest such as the social responsibility arrangement projects) and sanction- and punitive-oriented rules (punishments meted out to community members who disobey taboos set by authorities). These rules are socially constructed and include social safety networks. Kasanga (2001) explains the usurping rights of formal rules and the criminalisation of informal rules to land in Ghana. The fragmentation of forest institutional arrangements has led to several effects such as lack of access to forest livelihoods, forest conflicts and unsustainable forest management leading to rapid loss of forest ecosystem services. The formal rules in Ghana can be categorised into pre and post-independence laws. Key pre-independence forest legislations include the Timber Protection Ordinance No. 20 of 1907 and the Forest and Wildlife Policy and Trees and Timber Ordinance No.20 of 1948 (CAP 158). Most of the pre-independence laws focused on timber exploitation and restricted local property rights. Major key post-independence laws include the Trees and Timber Decree of 1974 (NRDC 273) and Timber Resources Management Regulations of 1998(L.I. 1649) which provided a good strategic framework for participatory forestry and enhanced conservation.

These formal rules tend to control accessibility of reserve and off-reserve forests and deliberately terminate the rights of local communities. This often leads to forest conflicts and restricts livelihood opportunities. The current tenure arrangements do not provide an acceptable framework for equitable benefit sharing of forest resources. There are national policies and regulations geared towards reforming some of the above institutional problems including the following: the forest fiscal reform, legal ban on chainsaw lumbering and other forest policies to support household livelihoods and sustainable forest management have failed due to unclear property right issues in the country.

Vietnam’s forest institutions, just like Ghana, have been influenced by both informal and formal rules, but the later explains the institutional arrangements and environment in Vietnam’s forestry. The reason for this is much more historical since Vietnam was an authoritarian centralistic government. After her Independence from the French in 1945, a socialist state forest was passed and implemented. The objective of forest management in the 1960s was to exploit timber and meet the demand of the economy through selective thinning and commercialisation. Management of forest in Vietnam in the 1960s and 1980s witnessed strict top level state management of forest resources (Sikor, 1998; Nguyen, 1999). The State controlled the forest sector till the late 1980s. The degree no. 15/CT/CTCW of 1961 clearly stated that “forests are properties of the entire people and have to be managed by the State”. This is very similar to the constitutional degree of Ghana (Concession Act of 1962) which stipulates that timber resources are owned and managed by the President on behalf of the people. This clearly demonstrates how formal rules are designed to usurp local rights of forest communities. The 1980s DoiMoi Reform tried to shift the country from central planning to a market-oriented economy and this had an influence on the forest economy (Ari, 1999).

Key Vietnam’s forest policy that changed forest management from the State through devolution is expatiated below accordingly.

The 1991 Law on Forest Protection and Development stipulated that forest resources could be allocated to diverse land users, including organisations and individuals, for management, protection and commercialisation. This law established a legal basis for setting up management boards for protection and special-use forests.

- In 1992, the National Programme 327 was launched, according to which individual households were entitled to annual contracts for the protection, restoration and regeneration of forest areas. Households could also be allocated cultivable land for agroforestry or agricultural purposes.
- In July, 1993, a Land Law was passed specifying that land users were entitled to long-term, renewable land use titles or Red Book Certificates (RBCs). This brought a new wave to forest management which took into account the right of forest owners, decentralisedand social forestry.
- On 15 January 1994, the government issued Decree 02/CP, ushering in a new trend in the managementforested and non-forested land, including natural forests. According to this decree, the State can allocate forest land to organizations, households and individuals for long-term (50 years) use in accordance with the uses stipulated for each forest type−production, protection and special use (Directorate of Forestry Vietnam, 2012).

These formal institutional reforms changed the economic, social and legal set up of the forest sector such as land classification, rules for forest protection, allocation of land use rights, and recognition of community as legal recipients. Other programmes that changed the forest outlook of Vietnam included the Programme 556, the Five Million Hectares Reforestation Project (5 MHRP) and the reform of the State forest enterprises. These reforestation efforts brought a turning point in the forest sector.

From the Vietnam case study, it may appear that formal rules single handedly regulate the management of forest resources, there are several roles played by informal rules before the introduction of most of these formal rules and informal rules are still relevant especially in ethnic minority communities. There are customary rules that govern individual behaviour and the management of forest resources. Xuan (2001) shows that ownership deals with social relations and access to and use of land and natural resources in communal forest. In traditional societies, land ownership is closely linked with marriage, inheritance and traditional structures, and existing customary rules and regulations define distributional rights, ownership, use and benefit sharing. The matter of village property rights entails various dimensions like the question of who decides on the distribution of natural resources, what is the process of distribution, who has the right to get the distributed resources, what are the rights and responsibilities of owners over these resources in communities. These traditional rules also sometimes conflict with the formal ones leading to conflicts.

3.4.3.2 Property rights

This section will consider forest property rights in both countries, taking into account formal and informal rules that impact on property rights practices regarding forestry. Property rights exist in multiple forms in both countries and define or delimit the range of privileges granted to individuals, communities and private or state enterprises.

Ghana’s forest property rights are mostly categorised into forest land ownership by traditional authorities or timber ownership by the State authorities and extend to their use, management, benefit sharing mechanisms in the forest sector. The major actors in these regimes are the land owners or farmers, forest fringe communities, private timber companies and small chain saw operators, forest administration and other interest groups in the sector mostly engaged in a competing property rights. The country is identified with the issue of legal pluralism since customary and statutory regulations coexist and sometimes create conflicts due to highly complex configuration of formal and informal tenure arrangements: The former mostly unwritten, is linked with traditional and local practices and it is location specific. The later on the other hand is codified, based on laws and enforced by governmental bodies (Kasanga, 2001; Kotey et al., 1998). The State Forestry Services has property rights over most of the forest in Ghana and manage the forest resources on behalf of the forest communities. In off-reserve forests, some households have access of use of forest resources in their farms, but even in these cases, off-reserve timber in farms are under the control of State Forest departments.

The structure of property rights in Ghana changed since the colonial masters passed the Forest Ordinance of 1927 which vested total property right to the State and usurped the rights of the indigenous communities (Gillis et al., 1988). This was also the birth of forest tenure problems in Ghana. This transfer wave of property rights changed management to the remaining forest and virtually eliminated the limited enforcement of environmental safe guards, once overseen by the traditional political authorities. These authorities wielded power based on their traditional symbol of ‘stool’ in southern Ghana and ‘skin’ of certain animal as the equivalent in the north as regalia. The constitution recognises these stool and skin lands and propertyrights vested in appropriate stool and skin on behalf of, and in trust for the subjects in accordance with customary law and usage and supervised by the Office of the Administrator of Stool Lands.

These constitutional stool and skin property rights are however very limited and still restricted by formal property rights.

Boakye et al., (2008) categorise eight types of forest property rights arrangements in Ghana: forest reserves, off-reserves forest, communal forests, community plantations, private plantations, industrial plantations, collaborative forest management and commercial plantations. Most of these arrangements are managed on off-reserve forest, except for collaborative forest management and commercial plantations tenure arrangements; these are managed mostly on forest reserves. They remark that these rights are mostly regulated by State Forest Agencies. The State enterprises enforce property rights, usually to the detriment of other stakeholders like forest fringe communities and the traditional authorities. Private forest ownership is not very common even though there are pockets of successful private afforestation and or reforestation efforts. There are also very few communal forestry that are collectively managed. This management scenario in Ghana puts management of forest resources in the sole hands of State agencies resulting in forest conflicts and high illegalities in the sector. However, there are some attempts in Ghana to engage the private sector through the allocation of forestlands to develop forest plans in programmes such as private plantations, Taungya system (access to land but not tree crops) covering an area of about 50,000 (ha) and the Modified Taungya System (Access to land and tree crops) covering an area of about 60,000 (ha) through the National Forest Plantation Development Programme (NFPDP) and the Forest Plantation Development Fund (FPDF). These national programmes are meant to transfer property rights from the State to private individuals. These attempts are still relatively small and the levels of commitment towards these reforms are relatively low. The Taungya system was introduced to restore forest cover and solve the land shortage problems for farmers living near forest reserves and provide labour to the Forestry Department. Forest management rights were given to small-scale farmers; rights to cultivate crops between the seedlings of a forest plantation for the first few years after planting. Even though this system includes benefit sharing and recognises farmers' tenure rights, the power play by the Forestry Department is still high in terms of benefit sharing. Vietnam's property right regimes, unlike Ghana, changed from collectivisation and State owned in 1950s to privatisation and individual land titling in 1990s even witnessed a decollectivisation of forestry (Sunderlin et al., 2008). Forest property rights changed in Vietnam over the last few decades and can be described with two ongoing trends: (1) the shift from top-down to bottom-up, participatory approach to forest management, and (2) the transformation from the only state-owned to multi-stakeholder management schemes (Nguyen, 2001).

This change in property right exercises greatly influenced forest tenure arrangement with increasing privatisation of land and uncertain collective rights (Sikor, 1998). The major actors in this regime change included private individuals, households, people, communities, management boards and State enterprises. The following explains the four current forest property tenure scenarios in Vietnam. (1) *Private property scenario:* Forest tenure rights arrangements are claimed by private household individuals. This arrangement offers the owners of the forest a long-term management and investment and they are entitled to a legal land-use certificate, Red Book Certificates (RBCs) for 50 years. (2) *State property scenario:* This tenure arrangement gives management rights to a State body for an unspecified period: mostly in a special-use or protection category and under State budget for the management of the forest. (3) *Common property scenario:* Tenure rights arrangement under this scenario is when the forest is under a collective owner of group/groups legally recognized by the State Authorities. (4) *Forest contracting scenario:* Tenure rights arrangement here is when an owner of forest (under State property) signs a contract with an organisation, household, and group of households or village to protect the forest. Under this arrangement, rights of ownership of the forest under contract remain with the contractor, and the contractee has only the rights specified in the contract. (Directorate of Forestry Vietnam, 2012).

Even though forest land use rights are currently under different scenarios with different forest user groups: state management boards (33%), state companies (15%), private household use (25%), land use not-yet-allocated (18%), and other entities (9%). Nguyen et al., (2010) conclude that private household use are now the second largest forest user group, sharing about 25% of forests and forest lands in 2010. This trend will rise in the coming years since the allocation of forest lands to farm households is not yet completed. We see an increased role of private forest property rights in Vietnam over the years. There is a transfer of property rights from a central state control to private households. The state allocated forestland and forests to households who belong to forest communities so that they could develop and manage them as a means of replacing centralised state control (Sikor, 1998). Household forestry gradually took the place of state forestry in management and became a primary unit in protecting forestland and forests ecosystem services. Households were given long-term land-use rights. Moreover, they also received technical support from forest enterprises and loans from banks. Some factors that influenced this trend included timber markets, infrastructure and economic development, globalisation and increased agricultural efficiency.

The emergence of private property rights in Vietnam led to an increase in total forest area and forest cover. It even becomes clearer why Vietnam's forest sector is among the "global top ten status" in afforestation and conservation of ecosystem services since the country has embraced forest devolution and decentralisation of forest resources with clearly defined property rights for years (Wilet al., 2006). With all its successes and achievements, there are still several empirical findings that criticise the property rights designs and the ambitious reforestation programmes in Vietnam (Sikor, 1998; Nguyen, 2006).

3.4.3.3 Sustainable livelihoods

This section analyses the quality of forest institutional property rights and forest livelihoods in Ghana and Vietnam. In section 2.4, we adapted the Sustainable Livelihood Framework to demonstrate how institutional processes and organisational structures ("political capital" formal and informal tenure arrangements) interact and create enabling environment in contributing to the pentagon assets in the framework: 1. Natural capital (land, timber, ecosystem services), 2. Social capital (forest communities' social safety networks) 3. Financial capital (farm and non-farm incomes) 4. Physical capital (roads, schools) and 5. Human capital (health, education). We further look at their interactions and influence on livelihood strategies (agro-forestry, livestock, agriculture and non farm activities) and finally leading to livelihood outcomes (household income levels , food security, forest conditions).

The empirical findings below shows the micro-macro linkages of institutional designs and their relations to livelihoods outcomes and forest conditions in Ghana and Vietnam. A classical empirical case of the vertical and horizontal linkages of the livelihood framework would be for example how the Social Responsibility Agreements (SRAs) and Timber Utilisation Permits (TUPs) as part of the institutional processes and organisational structures in Ghanian forestry impact on property rights and on the pentagon assets (new social facilities, increased social network particularly the role of traditional authorities, forest resources, household income etcs.) in Ghana. Another empirical case of these linkages in Vietnam would be for example how as part of the institutional processes and organisational structures (forest laws and national forest programmes) impact on the pentagon assets (new social facilities, increased social networks, forest resources, household income etcs.).We generally focus on how institutional property rights empirically can either support or hinder people's forest livelihoods and forest conditions in this section.

Secured forest property rights support forests fringe communities' household livelihoods and sustain the management of forest ecosystem services. In developing economies like Ghana and Vietnam, most households and small farmers depend on livelihood resources as their only livelihood strategy as elaborated in the Sustainable Livelihood Framework (DfID, 1999; Scoones, 1998; Falconer, 1994).

Ghana's forest institutional property rights however restrict farmers and forest fringe communities' access rights to the forest and forest resources and no incentive to sustain management of the forest and its ecosystems (Asare, 2010).This situation restricts forest communities of developing strategies to obtain their livelihood outcomes hence prevalent poverty in forest fringe communities'. The major cause of this pathetic scenario is the existence of unclear tenure rights and the dominance of formal tenure arrangements in the forest sector, which mostly frowns on informal rights and literally creates rural poverty in communities. Agidee (2011) elaborates the challenges faced by the forest sector and beats again the drum of poorly defined property rights as a major problem in the forest sector and its nagging negative externalities on forest conservation and sustainability. From the field survey conducted in Ghana in 2009 as indicated in Table 3.4, 96% of respondents from forest communities confirmed that they did not benefit from the Timber Utilisation Permits (TUPs). This is a benefit that forest communities are legally entitled to.

Table 3.4 Percentage of forest communities' benefits from TUP, SRAs and timber right resources

Forest Communities Position	Benefits from Timber Utilisation Permits (TUP) %	Benefit from Social Responsibility Agreements (SRAs) %	Access and control of timber tree resources %
No	96.0	96.0	88.0
Yes	4.0	4.0	12.0
Total	100.0	100.0	100.0

Source: FAOSTAT Forestry database 2010; OECD Statistics Database 2012

Our finding confirms with Marfo's (2012) explanation that forest resources benefited mostly timber companies. This result is not very different from the Social Responsibility Agreements (SRAs) benefits for forest communities, 88% of forest household communities interviewed were not satisfied with the current rights of access and benefit sharing for tree resources. These findings affirm that forest communities have several difficulties to use forest resources as a sustainable livelihood strategy in Ghana. These livelihood constraints by small farmers and poor forest fringe communities under the current tenure arrangements are well documented in Ghanaian forest literature (Agyare-Kwabi, 2004; Richards and Asare, 1999). Forest fringe communities' lack of access to, use and the unequal benefit sharing of timber and non-timber resources in both reserves and off-reserves. These have led to an increasing degradation and deforestation in Ghana's forest. As a result, the sector is characterised by illegal operations, forest conflicts, high level corruption, which are among a long list of property rights related problems in Ghana (Marfo, 2009).

The Vietnam's case study however reveals completely different picture from the Ghana's case. Nguyen et al., (2010) evaluates in detail the impact of forest institutional property rights in terms of land privatisation and afforestation incentives for rural households in Vietnam. They found that forest land privatisation helped sustain existing forest and enhanced rural households' livelihoods. Their studies applied a simple model of land use to identify the determinants of household decisions to afforest. They concluded that private led afforestation policies serve as an economic incentive for households and sustainable forest management. There are several empirical field studies that have found positive outcomes of forest property rights in household livelihoods in Vietnam, mostly linked with private tenure arrangement systems. There is equally enough evidence that Vietnam's secured property rights influenced the ambitious afforestation and reforestation programmes through devolution of forest rights from State to private individuals hence her forest transition story (Wil, et al, 2006;Nguyen, 2006). Most of these authors recognise an increase in forest devolution and defined property rights hence making the country an ideal "model" for sustainable forest management in developing countries. They equally accord that there are still some minimal sustainable forest livelihoods challenges. For example individual households with right of access to forest still find it difficult to acquire legal logging permits, so they collect timber without permits and there are also high illegalities in the forest sector (Sikor and To, 2011). Some critics of forest property rights in Vietnam claim that the State still acts like a "king" and the dominant player in the forest sector and local people manage mostly poor quality forest just like in Ghana (Clement et al., 2009; Sikor and To., 2011).

Most forest communities and poor households do not have secured tenure rights to access, use and manage forest resources in this country. In general, authors agree that forestinstitutional property rights in Vietnam could serve as incentives for household livelihoods but these have externalities and mixed successes. These successes depend on the local conditions and motivations before and after the implementation. However, the engagement of local people is a key factor in enhancing forest ecosystem services management and contributes to poverty alleviation.

3.4.3.4 Comparative Analysis of Forest Property rights and Sustainable Livelihoods

This section compares forest institutional property rights based on the following six forest property rights: (1) entering the forest area (access right); (2) using the forest land and withdrawing timber and Non Timber Forest Products (NTFPs) resources (use right); (3) managing the landscape and planning for future use, such as tree planting or timber management (management right); (4) determining who can and cannot use resources (exclusion right); (5) selling or transferring these rights to other parties (alienation right), and (6) the ease with which forest land holders' right extinguish legally (extinguishability). The extinguishability right could influence forest owners benefits to convert forest. In Ghana the current forest property rights reform attempt is geared towards a devolution of forest rights to forest communities, private individuals and reforestation efforts. Vietnam's forest tenure rights are mixed with private, state, common and contracting but with high forest devolution agenda already compared to Ghana. There are already existing property rights structures and instruments for forest management.

Table 3.5 Forest property rights in Ghana and Vietnam in perspective

Forest Property Rights	Ghana	Vietnam
Attributes		
Access	Increased	Consolidated
Use or Withdrawal	Increased	Consolidated
Management	External Control	External Control
Exclusion	Weak	Strong
Alienation	Weak	Strong
Extinguishability	Possible	Possible
Effects		
Livelihoods	Not Improved	Improved
Forest Conditions (forest cover and ecological conditions)	Worse	Better

Table 3.5 presents an overview of some of the findings on forest property rights scenarios in the case studies and an evaluation of their effects on household livelihoods and forest management conditions. The table classifies access and use rights under "no change", "increased" or "consolidated". In a "no change" status, the right to use or access to forest

resources is highly restricted. The “increased” status of right to use or access to forest resources implies that there is an increase in this right to forest communities. The “consolidated” status reflects a high level of this right to forest communities. Management rights either permit “local rules” or are dominated by “external control”-beyond straightforward regulations. The “local rules” status is defined as total management right to forest resources. This status gives forest communities absolute local rights without any control or regulation from a second or third party. The “external control” status represents management rights of key forest decisions by another party, mostly the State. Exclusion and alienation rights are classified as either “weak” or “strong”. The “weak” or “strong” status measures strength levels of these two positions.Extinguishability position represented as “possible” or “not possible”. The “possible” status represents the easiness at which forest property rights holders are legally extinguished by second or third party and “not possible” status, the opposite of the former. The impact of these property rights on livelihood and sustainable forest condition is extended from the normal bundle of rights theory in this paper so as to evaluate their effects and these are classified under “improved” or “not improved” in the livelihood position and forest conditions as “better” or “worse” accordingly.

The “improved” status is when livelihoods of forest communities are better off and “not improved” is when they are worse off and “better” status represents sustainable forest conditions in terms of net forest cover and ecological conditions and “worse” status is when forest management is unsustainable. These categorisations and definitions of the “statuses” help in the evaluation process of the study.

From the results presented, Vietnam’s forest property rights feature a consolidated forest access and use rights status with her numerous attempts to engage private property rights and local communities through devolution processes. Ghana on the other hand is still attempting to reach this status even though access and use right is increasing but not consolidated yet. The Forestry Commission in Ghana has more power and controls almost all forest resources. In both countries, forest management rights are still under external control; herein referring to the State, though Vietnam has implemented numerous decentralised and social forestry, major forest decision-making is still under the sole power of the Vietnam Department of Forestry just like the case study of Ghana. This result should not equate forest management rights of both countries, but rather to show the extent of the powerful role of formal rule in both case studies. It is worth mentioning that in Ghana however, some of these rights could be misleading, in the case when a land owner plants his or her own tree, then the landowner has higher right to use, manage, and even sometimes right to exclusion for the planted trees.

Exclusion and alienation rights clearly demonstrate vivid differences between Vietnam and Ghana. Vietnam's forest owners have a stronger right to sell or lease to other parties as well as right to exclude or define who has access to the forest resources than Ghana which is represented with a weak status for both rights. This further explain why, forest related livelihoods in Ghana have not improved compared to Vietnam since most of these property rights in Ghana are not assigned to forest communities hence benefits associated with these rights cannot be reached or are limited. Livelihood outcomes in Vietnam show an improved status since forest fringe communities and small landholders have better access to timber and NTFPs compared to Ghana. These weak or absent property rights in Ghana support our idea about the importance of secured exclusive rights, private, state or communal since it helps solve most of the property rights related problems. These institutional failures are as a result of weak safeguards regarding forest property rights, non participation in decision making and high poverty levels in the forest communities of Ghana. Conclusively, a weak institution is like a vicious cycle that leads to weaker property rights and increased illegalities, poverty in forest communities and worsened forest ecosystem services management (forest cover and ecological conditions).

Our results show that forest institutional property rights in Vietnam are much more secured and clearly defined than in Ghana hence Vietnam's higher status of livelihoods and forest cover and ecological conditions. These findings support our initial hypothesis that secured property rights of local communities enhance sustainable forest livelihoods and forest management conditions.

3.4.3.5 Lessons learned

Based on the review and findings in our paper, we are able to draw on some lessons from the case studies on institutional property rights and livelihoods. The lessons are categorised and summarised into 3 key levels and terms: (1) institutional, (2) property rights and (3) sustainable livelihood aspects. Institutional lessons learned include the fact that forest institutions have very complex, cross-scale and cross-level linkages hence making institutional analysis difficult, diverging and dividing debates. We propose research on local and contextual institutional analysis since there are a range of contextual factors that impact on institutional analysis and environment. Also, forest institutional related problems in the case studies revealed that, there is an urgent need to integrate formal and informal rules as a panacea for sustainable forest resource management in developing countries. The second aspect of lessons learned is specifically on property rights. Our research demonstrates the importance of secured exclusive property rights and clearly defined rights (state, private, communal) to weak or absent property rights with mostly wasteful outcomes. It must be noted however, that property right regimes even with clearly defined rules can still create some negative externalities based on local conditions, inherent contested interests among social groups in the forest sector. Enforcement, monitoring and evaluation of these rights are equally important for their sustainability. Sustainable livelihoods aspects contributed lessons to our study. A key finding in this regard is the integration of livelihoods in to institutional analysis, which is mostly not researched into or seriously considered. Our research calls for a redefinition of forest institutional property rights proposing sustainable livelihood aspect as key. Finally, a comparative case study analysis helps in detailing institutional property rights linkages in sustainable livelihood studies.

3.5 Conclusions and Policy implication

The following is a summary of the major findings of the analysis. Firstly, our paper contributes to the theoretical and empirical research gabs by identifying linkages and relationships between institutions, property rights and sustainable livelihoods frameworks and theories into one conceptual framework. Secondly, our review analysis suggests that, there are still several empirical research gaps in terms of integrating institutions, property rights and sustainable livelihoods in developing countries. Future research should explore their integration in order to address this significant research gap in forestinstitutional property rights. Thirdly, the evidence examined in this paper provides support for the argument that forest institutional property rights play important role in the livelihoods of forest dependent communities and in forest management, but that can be context specific. Fourthly, most studies we reviewed did not apply a case comparative analysis of property rights; hence our study took a critical micro review of both countries and their local conditions examined. This paper highlights the significant lack of this methodological approach and calls for the application of comparative case study methodologies in evaluating property rights effects on sustainable forest livelihoods and forest cover and ecological conditions.

Our study demonstrates that the anticipated role of forest institutional property rights in enhancing sustainable livelihoods and forest cover and ecological conditions is conditioned by several factors: Firstly, the issue of local contextual features needs to be considered. Secondly, their performance is strongly influenced by the type of tenure arrangements defined and the number of competing groups and stakeholders. Finally, the role of integrating formal and informal rules in defining property rights is strongly recommended in policy discourse.

Our findings call for connectivity and linkages of institutions, property rights and sustainable livelihoods since that has the potential to create a sustainable and efficient forest livelihoods, forest cover and ecological conditions. The paper calls for a “functional institution-clearly defined property right-sustainable livelihood outcome” framework in the forest sector. Our research can be extended in several ways, as a scope for future forest management research, we propose research on institutional property rights and livelihoods linkages since there are still relatively several research questions to be addressed, such as best ways to integrate comparative approaches for this kind of research. We equally need to test empirically most of the property rights theories proposed by applying both quantitative and qualitative methods.

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Chapter 4

Paper 3: Impact of Community Based Conservation Associations on Forest Ecosystem Services and Household Income: Evidence from Nzoia Basin in Kenya

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Impact of Community Based Conservation Associations on Forest Ecosystem Services and Household Income: Evidence from Nzoia Basin in Kenya

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ABSTRACT

Increasing the supply of forest ecosystem services in the tropics is on the agenda of most developing countries' forest policies and most importantly in Kenya which is a low forest cover country. Evidence from past empirical impact assessments show numerous limitations in these assessments such as complexities within local forest communities and challenges in accessing relevant ecosystem services and household income data for impact assessments. This paper attempts to address some of these limitations by estimating joint ecosystem services and household livelihood outcomes at the same time. A survey protocol was designed, pre-tested and implemented with 370 households in two (2) out of the ten (10) forest ecological conservancies in Kenya and with secondary data on selected ecosystem services outcomes. Propensity score matching estimates of the treatment effects of the treated from participation in conservation association show a significant income loss (−57600.11) for households participating in a conservation association with a positive effect on erosion control (3.49) and biodiversity conservation outcomes (0.071) in the Nzoia catchment area. The paper concludes recommending the introduction of a payment scheme with CBCAs household members in reforestation and afforestation programs in the Basin.

KEYWORDS

Ecosystem services; livelihoods; community-based conservation associations; propensity score matching; kenya

Introduction

Kenya's forest sector with a total area of 4,138,000 ha contributes significantly to its economy, a gross estimation of the sector puts the total annual Gross Domestic Product (GDP) contributions at 3.6% in 2015 (United Nations Environment Programme (UNEP), 2016). The national forest cover is estimated to be about 7.4%, below the national and legal requirement of 10% to get the country out of the so-called low cover forest countries by 2020 (United Nations Environment Programme (UNEP), 2016; FAO, 2020; Ministry of Environment and Forestry (MoEF), 2018). On the other hand, Kenya's closed canopy forest cover currently stands at about 2% of the total land area, compared to the African average of 9.3% and a world average of 21.4%. Rates of deforestation and forest degradation are high in

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Abstract

Increasing the supply of forest ecosystem services in the tropics is on the agenda of most developing countries' forest policies and most importantly in Kenya which is a low forest cover country. Evidence from past empirical impact assessments show numerous limitations in these assessments such as complexities within local forest communities and challenges in accessing relevant ecosystem services and household income data for impact assessments. This paper attempts to address some of these limitations by estimating joint ecosystem services and household livelihood outcomes at the same time. A survey protocol was designed, pre-tested and implemented with 370 households in two (2) out of the ten (10) forest ecological conservancies in Kenya and with secondary data on selected ecosystem services outcomes. Propensity score matching estimates of the treatment effects of the treated from participation in conservation association show a significant income loss (−57600.11) for households participating in a conservation association with a positive effect on erosion control (3.49) and biodiversity conservation outcomes (0.071) in the Nzoia catchment area. The paper concludes recommending the introduction of a payment scheme with CBCAs household members in reforestation and afforestation programs in the Basin..

Keywords: Ecosystem services, Livelihoods, Community Based Conservation Associations, Propensity Score Matching, Kenya.

4.1 Introduction

Kenya's forest sector with a total area of 4,138,000 ha contributes significantly to its economy, a gross estimation of the sector puts the total annual Gross Domestic Product (GDP) contributions at 3.6 % in 2015 (United Nations Environment Programme (UNEP), 2016). The national forest cover is estimated to be about 7.4% of the total land area, below the national and legal requirement of 10% to get the country out of the so called *low cover forest countries* by 2020 ((United Nations Environment Programme (UNEP), 2016; FAO, 2020; MoEF, 2018). On the other hand, Kenya's closed canopy forest cover currently stands at about 2% of the total land area, compared to the African average of 9.3% and a world average of 21.4 %. The rates of deforestation and forest degradation are high in Kenya, leading to losses of numerous ecosystem services such as carbon sequestration, biodiversity conservation, forest water recharge capacity and food supply. These have been the major national forest conservation challenges for the past two decades (FAO, 2020). Between 2000 and 2010, deforestation in Kenya's water towers amounted to an estimated 50,000 hectares. Due to the interdependence of various sectors, the decrease in regulating forest services as a result of deforestation caused a total of seven (7) billion Kenyan shillings (Ksh) in 2018[1], implying that the cost of limiting regulating ecosystem services as a production factor for the economy was 4.2 times higher than the actual cash revenue (UNEP, 2012; MoEF, 2018). This is as a result of the continuous loss of several timber, non-timber forest products (NTFPs) and other ecosystem services due to unsustainable practices such as slash and burn agriculture, overexploitation of wood resources and the utilisation of charcoal for household energy needs.

Sustainable forest management aims to enhance social, environmental and economic values of forest for the benefit of surrounding communities, as a result most tropical forest countries have designed partial or full forest management authority to local communities. This devolution is expected to lead to a more effective forest management, biodiversity conservation and provisioning of other ecosystem services and concomitantly contributing to poverty reduction and economic development in forest communities. Evidence of trade-offs in the supply of forest ecosystem services and increasing economic welfare of forest communities still persist in the forest literature. Specifically how to minimise these trade-offs in an optimal way and whether community based conservation associations could be one of the best approaches in addressing these trade-offs in Kenya.

[1] Exchange rate USD to KES, 1 USD = 103.628 KES (24.06.2018)

Forest management in Kenya through community forest associations and other conservation based groups was introduced by government, based on the recognition of the critical role of forest adjacent communities in ensuring increase in forest cover and improvement of household socio-economic conditions. In 2005, a new forest policy act was passed that guaranteed local users and beneficiaries of forest resources in forest management (Ongugo *et al.,* 2007). The Forest Act of 2005 provides opportunities to forest communities to form a legal entity referred to as community forest association (CFA). CFAs enter into an agreement with the Kenya Forest Service (KFS) to assist in the safeguarding of forest resources through protection and conservation activities (GoK, 2007). A similar act was passed in 2013, the Wildlife Conservation and Management Act of 2013 provides for the protection, conservation, sustainable use and management of wildlife in Kenya and for connected purposes. The Forest Conservation and Management Act of 2016 (No. 34 of 2016) makes a clear provision for community participation and management of forest resources in Kenya. These new participatory forest management approaches as stipulated in the revised national forest policy framework of 2014 puts emphasises on forest conservation and sustainable management through devolution and the promotion of private sector investment in gazetted forest reserves. This is further accompanied by concomitant institutional and organisational changes, notably the establishment of the Kenya Forest Service (KFS) and the formation of Community Based Conservation Associations (CBCAs). These associations are composed of both community forest and wildlife groups. CBCAs based on joint participation and management of forest entities, forest communities can access timber and non-timber forest products (NTFPs) as well as revenues from community-based forest industries, ecotourism and recreation, scientific and educational activities. The inclusion of communities is expected to enhance provisioning of ecosystem services, equitable distribution of benefits, conflict resolution, poverty reduction, and sustainable use (Kallert et al., 2000). The outcomes of community forest management and the role of community forest and wildlife associations and other conservation groups has been a focus of review in several studies in recent years in Kenya (Andre and Michael, 2014; Musyoki et al., 2013; Mogoi et al., 2012; Ongugo et al., 2007; Mutune and Lund, 2016).

These studies have renewed attention on the question of whether CBCAs improve sustainable forest management and socioeconomic conditions of forest communities or not and to what extent if they do in enhancing sustainable forest management. Most of the impact assessments on community conservation initiatives and their effects on sustainable forest management and socioeconomic improvements of communities have yielded mixed and conflicting results in the forest conservation literature. These studies suggest an increase or decrease in sustainable management of forest resources, making it difficult in establishing evidence on these linkages.

Moreover, there are several uncertainties in the findings and conclusions from the impact assessments on associations' outcomes. Despite the growing literature in community forestry, there is still lack of empirical case studies that can substantiate and quantify the impact on joint supply of forest ecosystem services and economic welfare improvements of CBCAs households in the Nzoia catchment area. There are numerous difficulties in CBCAs economic impact assessments due to methodological limitations, lack of access to baseline data, selection biases on outcomes, leakages and time scale measurements errors.

This paper advances the empirical work addressing some of these highlighted limitations in a number ways. First, it reviews the state of the art literature on CBCAs outcomes and develops a typology to understand the dynamics and drivers to join in these types of conservation instruments. This helps in the understanding of drivers of participation and captures the significant theoretical expectations in joining an association or not. Second, impact assessment literature on associations mostly focuses on forest conditions, this paper however examines multiple provisioning of forest ecosystem services and socioeconomic outcomes. Specifically, it identifies and describes critical indicators (forest ecosystem services and household income trends) in understanding their trade-offs. Third, the study uses household data from two conservancies in the Nzoia catchment area and hence provides an extension of previous assessments of associations in Kenya, mostly considering one specific case study area or locality. Finally, the study attempts to address some of the methodological limitations in assessments by taking into account detailed review of the literature, integrating for example data before implementation of conservation instruments, considering sample representation and rigorous discussions with various stakeholders on outcome indicators to be evaluated before applying the matching estimation technique.

The paper is organised into six sections, after this introductory section, section 2 focuses on a brief state of the literature on community forestry hypothesis in multiple supply of ecosystem services and household welfare improvement. Section 3 briefly reviews the literature. Section 4 presents the study design, covering the study area, data collection methods, analytical approaches and econometric specifications. The findings are discussed in section 5. The last section concludes by summarising key findings and implications.

4.2 State–of- the- art review on community vs protected-area hypothesis in ecosystem services supply and livelihoods

There have been much academic and policy interests in the role of community based conservation associations in sustainable forest management. The forest sector has witnessed a shift from a centralised state ownership and management to community institutions as a panacea to sustainable resource management (Ribot 2005; Persha et al., 2011; Duguma et al., 2018; Hajjar et al., 2020). These new approaches in forest management have rapidly spread in several developing and tropical countries and are designed to increase local participation and reconcile conservation and economic welfare of local communities and households (World Bank, 2007; Wood et al., 2019). Participation has been viewed as a pathway towards promoting efficient, effective, transparent and sustainable forest use. Furthermore, it improves socioeconomic livelihoods, benefits and opportunities for local communities and households. These conservation approaches address several challenges of forest governance, deforestation, degradation of forest ecosystem services and poverty in forest communities. The engagement of various actors, groups and stakeholders in forest management, particularly local participation and bottom-up approaches are often considered as one of the best alternatives to tackling household poverty and opportunity cost of forest conservation in developing economies (Gibson et al., 2000; Borner et al., 2009; Ongugo et al., 2007; Weiss et al., 2019).

The findings of recent assessments on the impact of community based conservation groups on forest cover and socio-economic conditions are mixed and still a subject of intense debate in forest economics literature (Coad et al., 2008; Lund et al., 2009; Sommerville et al., 2010; Hajjar et al., 2020). Two recent studies report that land cover change shows a consistent trend: deforestation is lower under community forestry. Nagendra et al. (2008) found lower deforestation and greater afforestation in areas under community management than the surrounding landscape in a Nepal country study. A study by Bray et al. (2008) in Maya Forest of Guatemala and Mexico found that deforestation rate in community forests is lower than in protected area forests. Most of these studies even though indicate a positive correlation of forest cover on community participation. However, their study designs do not eliminate the possibility that these differences had been present before community forestry management programmes were implemented (Bowler et al., 2012). The studies of Sreedharan and Dhanapal (2005) and Gautam et al. (2004) showed an increase in forest cover over the assessment period and Dalle et al. (2006) found a slight decrease in forest cover. The argument for decentralisation of forest management in developing countries is that shortage of resources and poor infrastructure have often resulted in a lack of effective state control (Curran et al., 2004). Devolving management rights and responsibilities to local people will avoid the 'tragedy of the commons' and encourage local people to actively manage the forest resulting in both ecological and economic benefits.

There are also a number of empirical case studies with negative conclusions towards community forestry on forest conditions and livelihoods outcomes. Kassa et al. (2009), in a modelling study compared participatory and non-participatory forest management using 26 datasets from an Ethiopian project, predicted income increase in non-participatory forest management compared with participatory management households in the medium term (< 7.5 years) but this predicted trend then reverses over a longer period (>7.5-30 years). There are also a number of empirical case studies with critical conclusions towards community forest participation. These studies uncover the persisting challenges of community forestry. They hint at its theoretical and practical limitations in developing country contexts. After an exhaustive review Bowler et al. (2012) found only eight studies made any attempt to control for selection bias in impact evaluation of community participation. These studies (Baland et al., 2010; Somanathan et al., 2009) found zero or small impacts (not always positive) on indicators such as basal stem area or forest cover. Jumbe and Angelsen (2006) applied propensity-score matching and decomposition techniques on household data from two forest reserves under a co-management program and concluded that while the program raises forest incomes for participants in one community, it reduces revenue for participants in the other, demonstrating a heterogeneity in the impact of forest devolution on incomes in the two community reserves. A study by Sundet and Moen (2009) on the political economy of Kenya showed how local participation can be too complex, lack of capacity to implement, and high risk of corruption in forest decentralisation resulting in mixed outcomes. Implementing participatory forest programmes comes with several costs and benefits. Predicting their outcomes empirically is still a challenge due to diversity of the programmes, local conditions, higher transaction costs associated with such programmes, and behavioural change of local communities among many others (Andersson et al., 2008). In addition, the findings of these studies on outcomes are mostly on forest cover and conditions with limited evidence on provisioning of multiple forest ecosystem services.

The evidence based outcomes on household welfare improvement are not equally different from the outcomes on forest conditions and forest cover. Gupta et al. (2012) found an increase in household incomes in a case study in India. Ali et al. (2007) conducted a study in Pakistan and found no difference in the number of income sources available to participatory forest management (PFM) and non-PFM households and only a small difference in primary sources of income (with a marginal increase in income from forest sources and small business activities, but less income from agriculture in PFM sites). Niesenbaum et al. (2005) identified an increase in forest-related income levels in Guatemala over a five-year period since project initiation. There is a conflicting result in the works of Kassa et al. (2009) on income outcomes. However, these studies suffer from methodological biases and lack of robustness as they do not completely provide convincing ground evidence that belonging to associations have any significant correlation on household incomes as most of them conclude. There were no long term available data to substantiate the predictions by Kassa el al. (2009) for example. Moreover, in Tanzania, Vyamana (2009) studied two types of community based conservation management practices, joint forest management and community-based forest management. Vyamanas' data shows a change in income from community forestry but for joint forest management type there was no clear trend, with conflicting findings between the two communities studied within each well-being category. Whereas with the community-based forest management type, the findings were more consistent. His study shows some potential biasness since he only showed data of four of the eight studied communities which were actively using participatory management and the other four communities not reported. Thus, only few forest impact assessments consider income outcomes in in community based forest management studies. Another striking finding from the review is the issue of timescales of assessment. Timescales of most impact studies are not reported or simply assessed within a short period during project implementation and evaluation. Evidence of CBCAs household members' participation on provisioning of ecosystem services and welfare improvement is a long process. Impact assessments should be conducted after a period of time of the intervention. Only a few studies analyse the effects of CBCAs on ecosystem services supply and livelihoods and take into account the issue of timescales, since management may change overtime following an intervention (Blomley et al., 2008).

Our study contributes to the literature and considers some of these challenges identified in the literature. It further addresses selection bias through randomisation and considers household welfare outcomes and joint provisioning of ecosystem services at the household levels.

4.3 Contextual Assessment-Community Based Conservation Groups in Kenya

Gazetted forest management in Kenya was founded on colonial antecedents of reservation and protection aimed at supplying wood for the colony (Thenya et al., 2008; Mugo et al., 2010). Designation of forest reserves, which occurred mostly in the colonial era (1895-1963), often involved displacement of local communities and/or exclude them from access and usufruct rights to land and forests. Postcolonial governments continued these policies of exclusion, and deliberately used them to further their own political and economic gains (Narh et al., 2016; Thenya et al., 2008; Standing and Gachanja, 2014). The forest department managed and controlled all forest resources. Existing evidence shows that this management approach failed and contributed to deforestation, forest degradation and loss of forest resources and ecosystem services as well as economic gains for forest communities (Marshall and Jenkins, 1994; World Bank, 2007).

Locally controlled forests through diversed family, community or indigenous resource right initiatives are better managed than state or private-sector alternatives in terms of increased livelihoods outcomes and forest biodiversity conservation (Bowler et al., 2012; Porter–Bolland et al., 2012; Macqueen, 2013). As a result, forest laws and policies in Kenya have been criticised for failing to protect indigenous forest, increased community forest plantations and other areas of forest and woodlands. Most forest fringe and adjacent communities are disadvantaged in forest management. Hence, a wave of several new legal instruments to ensure community and private sector engagement in forest management have been promulgated and promoted. These include the Forest Policy Act 2005, Land Act 2012 (No. 6 of 2012), the Land Registration Act 2012 (No. 3 of 2012), National Land Commission Act 2012 (No. 5 of 2012), Wildlife Conservation and Management Act 2013 and Forest Conservation and Management Act 2016 (Narh et al., 2016). These political instruments seek to balance the needs of local communities with opportunities for sustainable conservation, management and utilisation (Avishi et al., 2006; World Bank, 2007). Supporting the hypothesis that engagement and participation of CBCAs could sustainably enhance the management of forest ecosystem services and provide household livelihoods in Kenya.

Discussions on community based conservation groups in Kenya has been ongoing for decades but resonate with the national process of devolution under the above mentioned legal instruments.. These legal frameworks ensure communities to actively participate in community forestry through the formation of community forest associations (CFAs) and other conservation based groups like the Wildlife Conservation Associations (WCAs). Article 46(1) of the Forest Act for example states: "A member of a forest community may, together with other members or person's resident in the area, register a community forest association under the Societies Act, an association registered under subsection (1) may apply to the Director of Kenya Forestry Service for permission to participate in the conservation and management" (GoK 2005: 38). These associations are required to formulate forest management plans and sign management agreements with state agencies like the Kenyan Forestry Service and the Kenya Wildlife Service as preconditions for participating in community conservation initiatives. By year 2012, over 300 CFAs had registered across the country and many others were in the process of registration (Mogoi et al., 2012). This new community based conservation legal instruments has been heralded as a radical shift away from former forest policies that were characterized by fierce state control and exclusion of local communities (World Bank 2007; Mutune and Lund, 2016).

National reviews of these instruments however show mixed results, the recent work of Chomba et al. (2015) attempted to answer some questions on community based conservation initiatives in Kenya with a focus on how socio-economic differentiation is embedded in the historical political economy of allocation, alienation and dispossession of land and forest. Their results show that, rather than decreasing, community based conservation approaches instead increase vulnerability of disadvantaged groups and communities. These results are in tandem with Gelo et al. (2016) who found the impact of joint forest management with market linkages in Ethiopia to be biased upwards in favor of the upper end households in income distribution ladder. On the opposite site, a recent work of Mutune and Lund (2016) concluded that community forest association members have significantly higher forest-related incomes than non-members using a propensity score matching technique.

While a reasonable body of impact assessment literature have shown that community involvement in forest conservation has mixed outcomes in terms of improving forest conditions and welfare of forest communities and households. These studies haven't evaluated multifunctionality of forest ecosystem services combined with household livelihoods and welfare improvements. Most impact assessments failed to reduce potential biases in research methodology, lack access to data and have time scale measurement errors. Our study considers a very heterogeneous sample including conservation groups from the Kenya Wildlife Services and Forest Services. The study seeks to fill some of these empirical gaps with the field survey and selection of an appropriate estimation technique for impact assessment

Maseno University, National Alliance of Community Forest Associations), field surveys and interviews were conducted in two forest ecological conservancies out of the ten in the area (North Rift Conservancy-Trans-Nzoia Zone and Western Conservancy-Kakamega Zone). The Community Based Conservation Associations considered in this study include (1) Kipsaina Crane and Wetlands Conservation Group (Saiwa Swamp National Park-North Rift), (2) Community Forest Associations (Kiptogot CFA, Kimothon CFA, Malava CFA, Muileshi CFA-North Rift) (3) Kakamega Forest Reserve Conservation Arm (Kakamega Community Wildlife Association-Western) and (4) Non-Members of community-based conservation in these communities. The associations were heterogeneous since they included both CFAs, CWAs and a community based conservation group in Kipsaina which has a long history of community participation in conservation efforts.

4.4 Study design

4.4.1 Study sites

This study focuses on the Nzoai River Area within Lake Victoria Basin in Western Kenya (Figure 4.1) because the area is faced with many ecological and socio-economic challenges (climate change, ecosystem degradation, deforestation, vulnerability to poverty). Since 2000, productive agricultural areas have decreased by about 17% as compared to 1986, mainly due to changing weather patterns (Dulo et al., 2010). The situation is likely to continue over the coming decades as runoff is expected to decrease along with the land degradation (Simiyu et al., 2008). Climate change, anthropogenic and economic factors are causing degradation of ecosystem goods and services due to deforestation in the catchment areas, poor agricultural practices, and changing land use systems. Other major drivers include rapid population growth, weak and ineffective institutions, and limited non-farm employment opportunities.

The Basin traverses a vast area from Cherangani Hills, Mt Elgon, and the Nandi escarpment with its adjoining Trans Nzoia Plateau, all of which are considered the "water towers" of the Lake Victoria North catchment. Nzoia basin is located at latitudes 34º–36ºE and longitudes 0º03'–1º15'N in western Kenya, it has a semi-arid climate and covers an area of about 12,900 km^2. The Nzoia River drains into the Lake Victoria in the East African highlands and ultimately to the Nile river basin. The Nzoia river is a major source of water for more than three million people in western Kenya. The river supports agriculture and commercial sectors in the region, which is an important cereal and sugarcane-farming region, producing at least 30% of Kenya's output of both maize and sugar (NRBMI, 2006, Nyilitya et al., 2016). The Nzoia River basin supports not only western Kenya but also the broader Lake Victoria region.

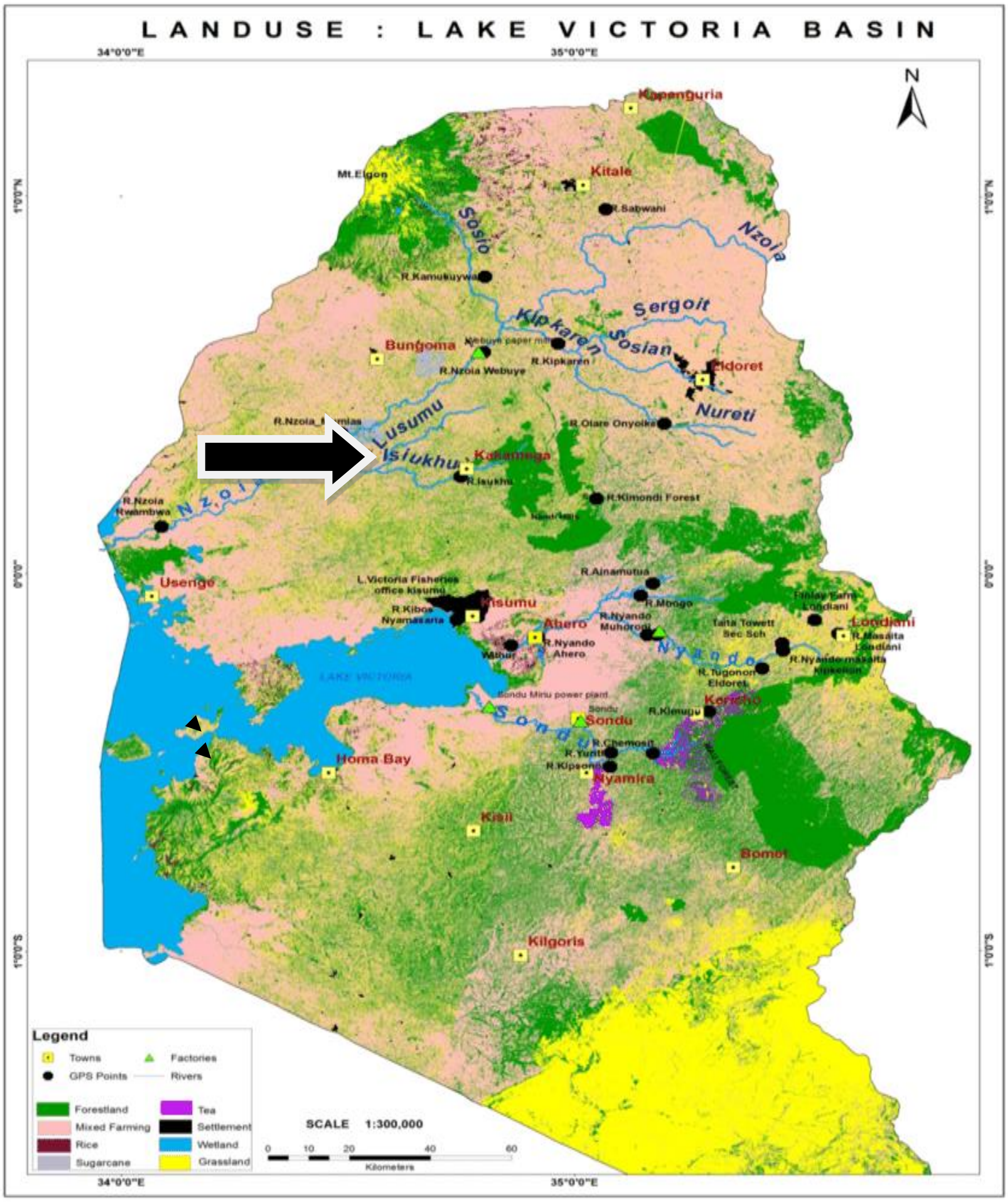

Figure 4.1 Map showing Nzoai Catchment Area with black arrow (left) within the Lake Victoria Basin and the land use types

Source: Nyilitya et al. (2016)

The local context of the catchment area allows a study on ecosystem services supply and livelihood outcomes based on its social-ecological systems and the number of community based conservation associations present. Based on consultation with key stakeholders in the Lake Basin (Kenya Forest Service, Kenya Wildlife Service, Nzoia River Basin Management and

4.4.2 Data collection and sampling method

Data collection procedure is described as follows. First, 240 households belonging to a community based conservation group and managing forest lands were sampled based on randomisation. Second, 130 non-CBCAs households who also manage forest lands were identified and interviewed randomly as counterfactual. The randomly selected 370 households were considered for the impact assessment from a total of 1000 households. Fig. A2 and Fig. A3 in the Appendix section show a set of small alighted area plots for the outcome variables for CBCAs and non CBCAs in the data set with outcome variable distributions. Most conservation groups and associations were created in the Basin since ten (10) years making the assessment feasible based on the time-lag between their creation and the evaluation. The study applied different methods such as participatory rural appraisal tools (key informant interviews, focus group discussions, participant observations and transect walks) to compliment the household surveys on forest management conditions and socio-economic characteristics.

Ten (10) key informants from the Kenya Forest Service, Kenya Wildlife Service, Nzoia River Basin Management and Maseno University, National Alliance of Community Forest Associations as well as executives of community based conservation groups were interviewed on the effectiveness of the intervention in addressing livelihoods and minimising ecosystem services decline in the Basin. Eight (8) focus group discussions were organised among the different association members and non-members on the strengths, weaknesses, opportunities and threats of community forestry. Farm visits and transect walks were conducted in all six (6) study areas within the two (2) zones in North Rift Conservancy-Trans-Nzoia Zone and Western Conservancy-Kakamega Zone. The field visits were conducted in Saiwa Swamp National Park, Kiptogot, Kimothon, Malava, Muileshi, and Kakamega to get a better understanding on management practices and type of agro- forestry systems undertaken by local communities and households. These tools complimented the survey data from the questionnaires administered and enhanced the quality of the data used in the study.

The data on ecosystem services outputs were based on literature reviews in the Basin (Stiebert et al., 2012; Schaab, 2015; Nyilitya et al., 2016) and complimented with ground data on forest carbon outputs, soil erosion control values and the use of deadwoods as biodiversity conservation indicator (RBMI, 2006; UNEP, 2016). These various data sources on forest ecosystem services were appropriate for the model and compared with other respective services in the study area from the literature. Integrating forest ecosystem services allows the authors to holistically understand the production processes compared to previous studies that only focused on forest cover net deficits and gains.

4.5 Analytical Framework

The theoretical underpinning of the econometric analysis used is in the following, individual welfare improvement *W* depends on a bundle of goods, an array *c*, which also includes services and material and immaterial goods and services. This welfare improvement function differs among individuals and among circumstances. The same bundle of goods can produce different levels of household welfare. The function therefore depends not only on the bundle of goods *c*, but also on other socio-economics characteristics of household members designated as *xi* . The welfare equation can be formalized as:

$$W_i = W_i(c_i; x_i) \quad \textbf{(1)}$$

In the equation (1), a household welfare improvement function W exists which gives each household member *i* a value of individual welfare *Wi* for every bundle of goods *ci*, under consideration of household specific factors *xi*. Suppose that the relevant bundle of goods as well as the characteristics can be observed, and that the individual welfare *Wi* can be calculated. Even under this assumption, drawing conclusions from these estimates with respect to household poverty and income distributions could be a problem. Poverty is not defined by only living standards, but choices and possibilities and capital available to each individual (Sen, 1981; Lambini and Nguyen, 2014). If a lower standard of living (measured in terms of the socially defined welfare function) is due (only) to preferences and not based on the restrictions an individual faces, then the individual generally is not considered to be poor. Hence equation (1), can be rewritten as:

$$W_i = W(c_i^*(r_i); x_i) = W(r_i; x_i) \quad \textbf{(2)}$$

where the resources of individual *i* are called *ri*. Welfare then is directly dependent on a bundle of goods *ci** which is dependent on resources *ri*. The bundle of goods *ci** may not necessarily be identical with the observable bundle of goods c_i, as preferences of the individual may differ from those preferences implied by the welfare function W defined by society. *ci**is the result of maximizing the socially defined function *Wi* subject to the available resources *ri*. Relevant for poverty definitions is this value of W_i depends on an optimization process theoretically restricted by available resources. This goes in line with the well-known resource definition of poverty by Sen (1981) and Strengmann-Kuhn (2000). These theoretical assumptions apply not just to household economic welfare but also in the maximisation of timber production and ecosystem services by forest land owners and users and the outcomes of this production depends also not only on c, but socio-economic features of households. Following this resource definition of welfare, we construct a regression model where CBCAs serves as a resource augmenting instrument such as:

$$Y_i = \alpha_0 + \alpha_1 C_i + \alpha_2 R_i + \alpha_3 H_i + \varepsilon_i \tag{3}$$

Household income Y is a function of the CBCAs status (C), productive resources (R), and household characteristics (H), while ε is the error term.

4.5.1 Empirical econometric specification

Base on Roy (1951), we assume that a household decides whether to participate in CBCAs or not based on expected utility maximization. If the household expects to benefit from participating in such an association, then it will join. We define the $i = 1 \ldots N$ in treatment regimes $= \{0,1\}$, where 1 represents participating in the CBCAs and 0 otherwise. Hence,

$$D_I = 1 \text{ if } V_{i1>}V_{i0.} \tag{4}$$

where Y_{ij} is a vector of the potential outcome variables; Y_{i1} is the household welfare improvement outcome and forest ecosystem services provisioning outputs of CBCAs households and Y_{i0} is the household welfare improvement outcome and forest ecosystem services provisioning outputs of non-CBCAs households. The difference between Y_{i1} and Y_{i0} is used to define the treatment effects on household welfare improvement and ecosystem services outputs. The treatment effect of the household outcomes (welfare improvement and ecosystem services) depends on the counterfactual situation. The randomisation of the CBCAs and Non-CBCAs sampled households allow us to control for outliers, selection biases, and unobserved heterogeneity. The treatment effect is determined by a propensity score matching specification based on Heckman et al. (1998). The implementation of this propensity score matching includes two stages. The first stage is a generation of propensity scores from a linear regression model using the household socio-economic and demographic and community level characteristics and other controls as covariates. Based on the scores, we construct a new control group by matching the CBCAs and non-CBCAs households according to their given scores through the matching method. The second stage involved computation of the treatment effects which are the differences in the outcome variables between CBCA member and non-member households using the matched observations. These effects are the mean difference in Y (welfare and ecosystem services) for CBCAs and non-CBCAs households (Y_{i1} and Y_{i0}) as defined previously. The matching was implemented via the psmatch2 (Leuven and Sianesi, 2003). By default, psmatch2 approximates standard errors on the treatment effects assuming independent observations, fixed weights, homoskedasticity of the outcome variable within the treated and within the control groups and that the variance of the outcome does not depend on the propensity score.

4.5.2 Data description

Table 4.1 describes the collected data. Variable household income ($totalincome$) represents the welfare. The ecosystem services outcome variables include the total carbon stock ($carbonstock$) in the land area managed by households. It is the function of the above ground biomass and below ground biomass at the forest managed by each household and also compared with the available carbon ecosystem services assessment in the basin. The second ecosystem services outcome is soil erosion control ($eroscontro$) which was based on the universal soil loss equation (USLE) model (Wischmeier and Smith, 1978; Ssegane, 2007) and applied to the Nzoai Basin. The biodiversity outcome indicator is a dummy variable ($deadwood$) if forest owners kept deadwoods for biodiversity conservation ($deadwood$ =1; otherwise =0). We control for different individual and group behavioural characteristics such as age, education level, main occupation, non-farm income, and whether the household owns land or not. Forest management and structure variables included in the covariates of the model include the membership to a conservation group, forest type, growth stage of forest, forest size and forest composition management (see Table 4.1).

Table 4.1 Descriptive statistics (370 observations)

Variable	Description	Mean	Std. Dev.	Min	Max
ownla	Land ownership (no=0, yes=1)	0.97	0.17	0	1
cbcamem	Membership to a conservation group (no=0, yes=1)	0.65	0.48	0	1
cbcafotype	Forest type in property	2.69	1.96	1	6
forstag	Stage of forest	2.32	1.96	1	7
forsize	Forest size (ha)	3.14	2.19	0	6
formacompo	Forest management composition	2.65	1.34	1	6
age	Age of respondents (years)	3.08	0.76	2	4
educat	Level of education	3.65	1.49	1	8
occupa	Occupation type	2.55	1.33	1	7
incomesou	Sources of income	3.81	1.41	1	7
nonfarmince	Non-farm income	0.78	0.42	0	1
totalincome	Total annual income (1000 Ksh /year)	128.42	150.20	44.87	890.00
carbonstock	Tonnes of carbonstock (t/ha)	33.96	17.59	1	78
eroscontrol	Erosion control (ton/ha/year)	31.28	16.01	5	64
deadwood	Deadwood availability	0.74	0.44	0	1

4.6 Results and discussion

We supplemented our propensity score matching with econometric regression. The following four (4) tables present the estimation results on variables household income ($totalincome$ in Table 4.2), carbon stock ($carbonstock$ in Table 4.3), erosion control ($eroscontro$ in Table 4.4, and deadwood ($deadwood$ in Table 5.5). Since the dependent variables in the first three regressions are continuous, we used the ordinary least squares method. The dependent variable in the last regression is a dummy, we used the probit model. The average treatment effects estimated from the propensity score matching are summarised in Table 4.6 while details of the matching are reported in the Appendix section.

With regard to the regression results, Table 4.2 shows that the income effect of participation on household income is insignificant. Meanwhile, the effects of forest size and forest composition are significant and positive. Table 4.3 shows that participation in a conservation association increases significantly carbon stock outcomes but ownership of forest land does not have a significant effect although the estimated coefficient is positive. Other variables that have positive and significant effects include forest stage, forest type, and the number of income sources. Meanwhile, the variables that have significant and negative effects on carbon stocks include forest type in property, forest composition and non-farm income. The negative effect of non-farm income is not surprising since most of this income source is outside the forest and agricultural household activities. Table 4.4 shows that participation in a conservation association has a positive but insignificant effect on soil erosion control. The size of the forest positively increases soil erosion control services as anticipated in the forest ecosystem services literature. Table 4.5 presents the estimation results of the probit model on variable deadwood as the proxy for biodiversity conservation.

Table 4.2 Linear regression estimates on outcome total income

Dependent variable: *totalincome*	**Coefficient**	**Std. Err.**	**z**
ownla	2287.27	51208.86	0.12
cbcamem	-46870.21	38981.77	-1.20
cbcafotype	88276.84	67532.07	1.31
forstag	-114879.40	122386.30	-0.94
forsize	106898.00	68607.49	-2.14**
formacompo	74400.00	38184.37	1.95*
age	-66876.92	56886.37	-1.18
educat	49920.49	61499.53	0.81
occupa	323.24	52970.09	-0.01
incomesou	74532.27	64684.49	1.15
nonfarmince	79324.55	105876.40	-0.75
constant	202962.50	135409.20	1.50
Model statistics			
No. of observations	370		
F	2.00		
Prob > F	0.001		
R^2	0.17		
Adjusted R^2	0.08		

* Significant at 10%, ** significant at 5%

Table 4.3 Linear regression estimates on outcome carbon stock

Dependent variable: ***carbonstock***	**Coefficient**	**Std. Err.**	**z**
ownla	3.88	2.98	1.30
cbcamem	41.97	2.27	1.85*
cbcafotype	-12.66	3.93	-3.22***
forstag	41.15	6.39	6.44***
forsize	19.70	4.59	4.29***
formacompo	-49.06	5.28	-9.28***
age	1.32	2.99	0.44
educat	-3.33	5.30	-0.63
occupa	-25.92	8.30	-3.12***
incomesou	18.45	3.21	5.75***
nonfarmince	-5.09	2.22	-2.29***
constant	40.08	7.87	5.09***
Model statistics			
No. of observations	370		
F	2.00		
Prob > F	0.000		
R^2	0.79		
Adjusted R^2	0.08		

* Significant at 10%, *** significant at 1%

Table 4.4 Linear regression estimates on outcome erosion control

Dependent variable: ***eroscontrol***	**Coefficient**	**Std. Err.**	**z**
ownla	1.70	10.18	0.17
cbcamem	34.03	4.22	1.43
cbcafotype	20.18	11.47	1.76*
forstag	-5.30	7.31	-0.72
forsize	15.96	6.44	2.48***
formacompo	7.95	5.73	1.39
age	-3.38	6.16	-0.55
educat	-7.77	6.27	-1.24
occupa	-63813.67	67176.32	-0.95
incomesou	3.05	7.27	0.42
nonfarmince	-0.49	7.00	-0.07
constant	19.00	14.66	1.30
Model statistics			
No. of observations	370		
F	1.63		
Prob > F	0.02		
R^2	0.14		
Adjusted R^2	0.05		

* Significant at 10%, *** significant at 1%

Table 4.5 Probit regression estimates on outcome dead wood

Dependent variable: ***deadwood***	**Coefficient**	**Std. Err.**	**z**
ownla	6.10	898.80	0.01
cbcamem	1.23	0.53	2.32***
cbcafotype	6.11	898.80	0.01
forstag	-0.19	1182.38	-0.00
forsize	2.67	6494782.00	4.11***
formacompo	9.07	1144.92	0.01
age	5.73	4.09	-1.40
educat	3.24	884.78	-0.01
occupa	-63813.67	67167.32	0.95
incomesou	74532.27	64684.49	1.15
nonfarmince	4.20	898.79	-0.00
constant	1.18	0.67	1.76
Model statistics			
No. of observations	370		
LR chi^2	142.98		
Prob > chi^2	0.000		
Pseudo R^2	0.76		

*** significant at 1%

Table 4.6 The treatment effects of the treated (ATT) from the participation in CBCAs

Outcome variable	**ATT**	**Direction of effect**
Income	- 57600.11	-
Carbon	- 0.73	-
Erosion control	3.49	+
Deadwood	0.071	+

Notes: − means decrease likelihood of outputs, + means increase likelihood of outputs. Full results for all estimations are reported in the appendix section

Regarding the propensity score matching, the average treatment effects on the treated are given by the differences in outcome variables ($totalincome,\ \ carbonstock$, $eroscontro$ and $deadwood$) for the treatment and control groups and presented in Table 4.6. The results show that there is actually a significant lost in income for households participating in a conservation association even though the effects on erosion control and biodiversity conservation are positive. These results confirm that community based conservation groups play important role in increasing forest ecosystem services in the Nzoia catchment area. However, there is the need for compensation payments to households engaged in conservation groups sincere there is a loss in their total incomes. These findings are consistent with the works of Börner et al. (2009)

calling for payment for the opportunity costs of conservation in the Kakamega Forest and Chomba et al. (2015) study in Kenya, which suggest community-based conservation instruments increase vulnerability of disadvantaged groups and communities hence reduction in their economic empowerment. These results support the recent review of Hajjar et al. (2020) who provide global evidence on the multifunctionality of forest ecosystem services with community forestry and the complexities in measuring their outcomes. Designing and implementing household payment schemes for provisioning of multiple forest ecosystem services with communities is critical to conservation and reducing deforestation and increasing forest ecosystem services supply in the Basin whilst sustaining household incomes in the study area.

4.7 Robustness check and model benchmarking

Even though this is a nonexperimental study, the survey protocol processes applied random sampling technique to ensure representativeness in our sample of the treated and control groups to ensure robustness.

Using the psmatch2 model, we constructed a control group that is statistically comparable to the treatment group. The study implemented the -pstest- command to test covariate imbalance after matching, the balancing property was satisfactory based on our model estimation results. This counterfactual analysis allows calculating the effect of the intervention under study on outcome variables of interest since the methods calculate approximate standard errors on the treatment effects, assuming independent observations, fixed weights, homoskedasticity of the outcome variables within the treated and within the control group through balancing property of the propensity scores (Rosenbaum and Rubin, 1984; Rosenbaum, 2002; Caliendo and Kopeinig, 2008).

A test based on the comparison of means for each covariate between treated and matched controls shows that the difference is small hence we accept the hypothesis that the treated and matched control samples are balanced. To enhance robustness of our estimates, knowing that unobserved determinants of the nontreated outcomes can affect our intervention over time, we tested further the intervention on unobserved characteristics. The study bootstrapped (500) replications of the survey samples, because the estimators are asymptotically linear, this leads to a valid bootstrap standard errors of the statistic for the four treated outcomes and approximate sample distributions effect in the original propensity score-matched sample reported in appendix tables A.3 (a), A.3 (b), A.4 (a) and A.4 (b) -37962.24; 7.682674; 3.379801;

.1159486 respectively. These score results demostrate that the standard errors are correctly estimated and valid for statistical inference since they are closer to the empirical standard deviation of the sampling distribution of estimated effects. Similar comparisons of the t-stats of the unmatched and ATT samples for the four outcomes reported in the appendix tables A.3 (a), A.3 (b), A.4 (a) and A.4 (b) with the following corresponding results - 0.11 and 0.62; 6.28 and 0.12; 0.86 and 0.75; 9.53 and 0.48 respectively, suggest there is no statistically significant difference in outputs between the matched treated and the control validating our propensity matching models. A further comparison of our Pseudo-R2 before and after matching also shows no systematic differences in the distribution of covariates between both groups.

These results show that our model fits the set of observations and data and propensity scores are well estimated. Moreover, a sensitivity analysis of the estimated results with respect to deviations from the conditional independence or unconfoundedness assumptions and unobserved simultaneity with the treatment and outcome variables were estimated. Based on the bounding approach proposed by Rosenbaum (2002), the study applied mhbounds sensitivity analysis which allows determining how strongly an unmeasured variable can influence the selection process in order to undermine the implications of the matching analysis. Our robustness checks show that inference about treatment effects are not altered by unobserved factors.[2] These tests further confirm robustness of our model estimates since it finds no alteration by the unobserved factors and the model adequately and significantly fits the data.

4.8 Conclusions and policy implications

The evidence from our analysis shows significantly the role of Community Based Conservation Associations (CBCAs) in joint supply of forest ecosystem services. This is consistent with some recent empirical literature, however, our study extends further the literature by the integration of forest ecosystem services and economic welfare conditions of households as joint outcomes in the study area. Furthermore, the income results show a significant decrease indicating that sustainable forest management policies in the Nzoai catchment area should considerably recognise payments schemes as a means to incentive households in community conservation instruments. Payments schemes should be designed with CBCAs in rehabilitation of degraded and over-exploited dry forest areas, and encourage associations in tree planting in the basin area. The results suggest a flat per hectare forest incentive payment scheme with households. Our study results reinforce the calls for

[2] Results from the mhbounds are not presented but available upon request from authors.

engagement of community based conservation groups in joint supply of forest ecosystem services outcomes but this can be implemented with additional subsidy payments to households with access to forest lands and managing their forests in communities in the Basin. The implementation of forest policies should identify practical strategies to engage these types of associations in sustainable forest management.

Methodologically, our comprehensive empirical analysis with observational data shows that propensity score matching could be a powerful alternative evaluation method in measuring the average effect of the treatment on the treated in forest conservation policy in a nonrandomized setting, this is based on suite of statistical tests from the study that give a robust and validated results.

The paper to the best of our knowledge is the first to apply a propensity score matching technique in finding evidence of joint ecosystem services and livelihood outcomes of community based conservation groups in the Nzoai catchment area. It is worth mentioning that the study however have some limitations, since our survey data are cross-sectional in nature, there are certain limitations in estimating observations over time on the participants-time-lag-dimension issue. In addition, this cross-sectional nature of data does not allow us to control for time-invariant and variant unobservable factors in the model.

Appendix

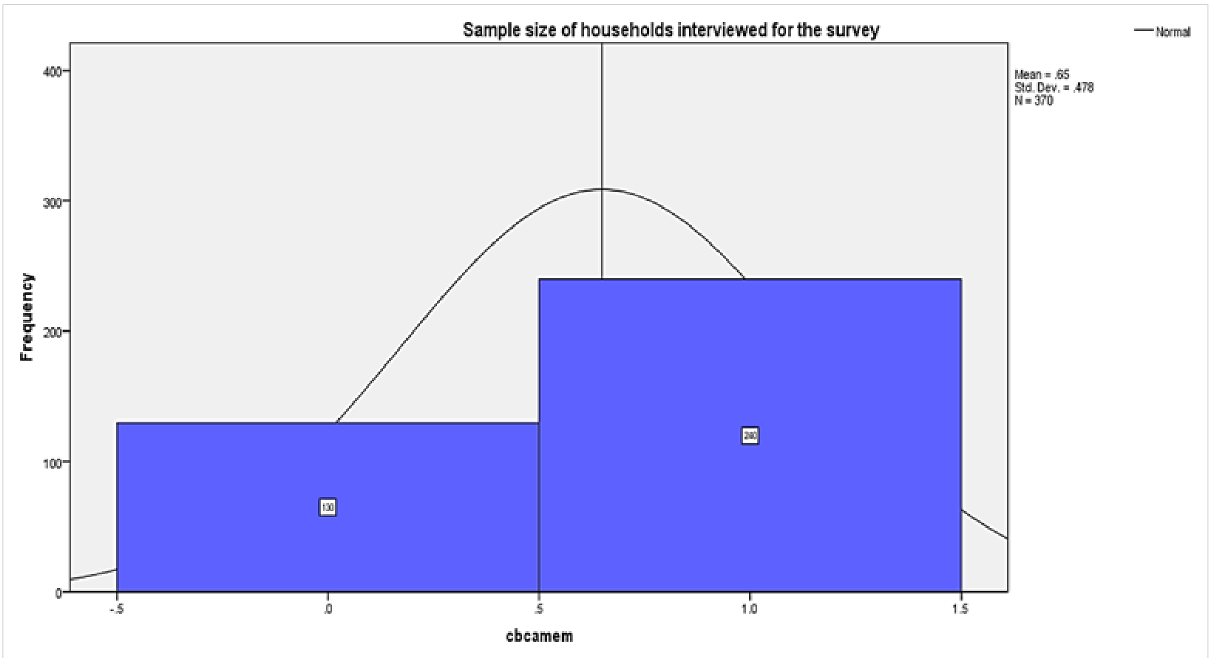

Figure A. 1 Sample size of household members interviewed during the survey

Stratified random sampling technique was applied in the section of the population sample. Power calculations were performed to assess sample size. This sample was representative of the major conservation based groups in the area who had forest lands and also Non-CBCAs households as a control group for the study. A survey protocol was designed, pre-tested and implemented in the two forest ecological conservancies out of ten in Kenya.

We construct a set of small alighted area plots for the outcome variables for CBCAs and non CBCASs in the data set. Each plot shows the distribution of the outcome variables (welfare total income, carbonstock, deadwood and erosioncontro) in the control and treated subgroups and overlaid on the distribution of the entire dataset. This has the advantage of generalizing the treated and control groups and allows simultaneous comparison of multiple variables of each group.

The results from the Ggraph for CBCAs households show that income from the treatment groups is rather lower compared to the Non CBCAs household with a 52.08%, representing 3.3% difference of higher welfare improvement.

With the carbonstock of the CBCAs there are higher percentages representing 15.83% and 13.75% totalling 29.59%, compared to the 20.77% for the Non CBCAs households. Deadwoods show a higher percentage also with 95.83% of deadwood presence and 4.17% of no deadwood.

Erosion control equally shows 13.75% compared to the 10% for Non CBCAs representing a difference of 3.75%.

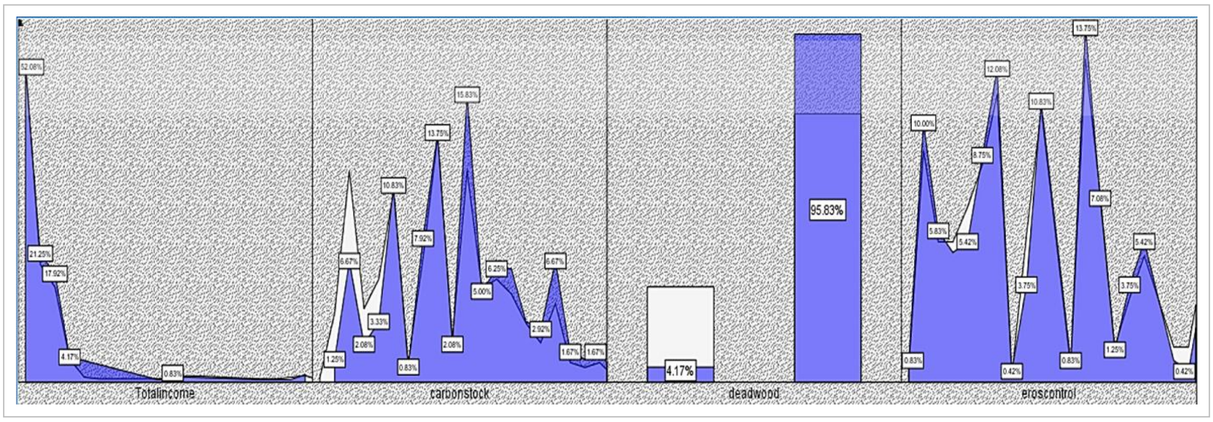

Figure A. 2 GGraph CBCAs Household Outcomes (Treatment Group)

The results from the Ggraph for Non CBCAs households show that income from the control groups exceeds the treatment group, with about 55.38% having higher total income and 16.15% also having higher income and with just 0.77% having lower income. Carbonstock shows 20.77% and 13.08% and the least representing 0.77%. Deadwood represents 66.92 and 33.08% for presence of deadwood and no deadwood respectively. Erosion control had about 10% producing this ecosystem service and 9.23% and the least 1.54%.

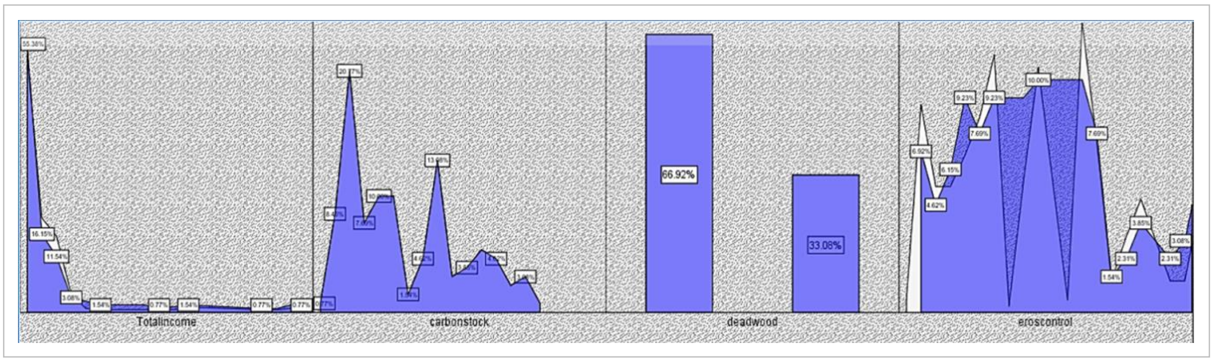

Figure A. 3 GGraph CBCAs Household Outcomes (Control Group)

Table A. 1 Propensity Score Matching Model of the effects of CBCAs on income

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
totalincome	Unmatched	110981.789	112915.393	-1933.60379	18266.1267	-0.11
	ATT	110981.789	168581.898	-57600.1094	92357.7211	-0.62

Table A. 2 Propensity Score Unmatched Model of the effects on income

```
Bootstrap replications (500)
----+--- 1 ---+--- 2 ---+--- 3 ---+--- 4 ---+--- 5
..................................................    50
..................................................   100
..................................................   150
..................................................   200
..................................................   250
..................................................   300
...........................................x......   350
..................................................   400
..................................................   450
..................................................   500
Linear regression                           Number of obs     =        184
                                            Replications      =        499
                                            Wald chi2(1)      =       0.00
                                            Prob > chi2       =     0.9594
                                            R-squared         =     0.0001
                                            Adj R-squared     =    -0.0054
                                            Root MSE          =   1.14e+05
```

totalincome	Observed Coef.	Bootstrap Std. Err.	z	P>|z|	Normal-based [95% Conf. Interval]	
_treated	-1933.604	37962.24	-0.05	0.959	-76338.23	72471.02
_cons	112915.4	33524.59	3.37	0.001	47208.41	178622.4

The propensity scores difference from Table A.1 shows a large and negative income outcome specification in both households for the unmatched and the matched average treatment effect on the treated.In the estimation result, the ATT for the matched sample is larger (- 57600.109) than that of the unmatched sample (- 1933.604). This result shows that conservation based forest management comes at a cost since there is a significant high reduction in household total income for the results of ATT and the matched samples as well as for the unmatched sample. CBCAs members need about 57,600.109 Kenyan schillings (Ksh) annually as an additional income for their efforts in provisioning of ecosystem services and sustainable management of their forest. These income findings are in line with other forest management studies that recommend payments due to additional cost in provisioning of public goods in the tropics (Engel et al., 2008; Mustalahti et al., 2012 ; de Leeuw et al., 2014).

Table A. 3 Propensity Score Matching Model of the effects of CBCAs on carbonstock

```
> ────
      Variable      Sample |    Treated     Controls   Difference         S.E.   T-
> stat
───────────────────────────┼──────────────────────────────────────────────────────
> ────
   carbonstock   Unmatched | 41.1015625   25.0357143   16.0658482   2.55867779
> 6.28
                       ATT | 41.1015625   41.8359375    -.734375   5.89221868    -
> 0.12
───────────────────────────┴──────────────────────────────────────────────────────
```

Table A. 4 Propensity Score Unmatched Model of the effects of CBCAs on carbonstock

```
Bootstrap replications (500)
    ┼─── 1 ───┼─── 2 ───┼─── 3 ───┼─── 4 ───┼─── 5
..................................................    50
..................................................   100
..................................................   150
..................................................   200
..................................................   250
..................................................   300
..................................................   350
..................................................   400
..................................................   450
.................x................................   500

Linear regression                               Number of obs      =        184
                                                Replications       =        499
                                                Wald chi2(1)       =       4.37
                                                Prob > chi2        =     0.0365
                                                R-squared          =     0.1781
                                                Adj R-squared      =     0.1735
                                                Root MSE           =    15.9700

──────────────┬────────────────────────────────────────────────────────────────
              │   Observed   Bootstrap                         Normal-based
 carbonstock  │      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
──────────────┼────────────────────────────────────────────────────────────────
     _treated │   16.06585   7.682674     2.09   0.037     1.008084    31.12361
        _cons │   25.03571   5.888866     4.25   0.000     13.49375    36.57768
──────────────┴────────────────────────────────────────────────────────────────
```

The propensity scores difference from Table A.3 shows a rather positive and significant carbonstock provisioning for the unmatched and raw sample. Comparing the ATT and unmatched values shows that the unmatched treated increased the likelihood of forest carbonstock by 16.07 tC02/ha/yr. This positive probability indicates that CBCAs could be an alternative approch to reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in the Nzoai catchment area.

The ATT scores show rather a reduction in the likelihood of carbonstock from the matched sample, this results show that after matching there is rather a negative impact on carbon, this could be due some of the missing values in the carbonstock variable and stated carbon outputs from the sample. The recent study of Muchemi et al., 2015, confirms our findings for an active community engagement in carbon provisioning in Kenya.

Table A. 5 Propensity Score Matching Model of the effects of CBCAs on erosion control

```
> ——
      Variable     Sample |    Treated     Controls   Difference         S.E.    T-
> stat
——————————————————————————+———————————————————————————————————————————————————————
> ——
   eroscontrol  Unmatched |     30.875   28.7857143   2.08928571   2.43664178
> 0.86
                      ATT |     30.875   27.3828125    3.4921875   4.64831915
> 0.75
——————————————————————————+———————————————————————————————————————————————————————
```

Table A. 6 Propensity Score Unmatched Model of the effects of CBCAs on erosion control

```
Bootstrap replications (500)
----+--- 1 ---+--- 2 ---+--- 3 ---+--- 4 ---+--- 5
..................................................    50
..................................................   100
..................................................   150
..................................................   200
..................................................   250
..................................................   300
..................................................   350
..................................................   400
..................................................   450
..................................................   500

Linear regression                               Number of obs      =       184
                                                Replications       =       500
                                                Wald chi2(1)       =      0.38
                                                Prob > chi2        =    0.5365
                                                R-squared          =    0.0040
                                                Adj R-squared      =   -0.0014
                                                Root MSE           =   15.2083

------------------------------------------------------------------------------
             |   Observed   Bootstrap                         Normal-based
eroscontrol  |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    _treated |   2.089286   3.379801     0.62   0.036    -4.535002    8.713573
       _cons |   28.78571   3.093936     9.30   0.000     22.72171    34.84972
------------------------------------------------------------------------------
```

Table A. 7 Propensity Score Matching Model of the effects of CBCAs on deadwood

```
> ────
       Variable      Sample |    Treated     Controls   Difference          S.E.   T-
> stat
> ────
       deadwood   Unmatched | .980952381           .3   .680952381    .034867087    1
> 9.53
                        ATT | .980952381    .90952381   .071428571    .150004249
> 0.48
```

Table A. 8 Propensity Score Unmatched Model of the effects of CBCAs on deadwood

```
Bootstrap replications (500)
────┼─── 1 ───┼─── 2 ───┼─── 3 ───┼─── 4 ───┼─── 5
........x.........................................    50
........x..x....................x.................   100
..................................................   150
..................................................   200
.....x.........x......x...........................   250
............................x...........x.........   300
......x...........................................   350
....................x.............................   400
..................................................   450
..........x.......x................x..............   500

Linear regression                               Number of obs     =        184
                                                Replications      =        500
                                                Wald chi2(1)      =      34.49
                                                Prob > chi2       =     0.0000
                                                R-squared         =     0.5614
                                                Adj R-squared     =     0.5599
                                                Root MSE          =     0.2767
```

deadwood	Observed Coef.	Bootstrap Std. Err.	z	P>|z|	Normal-based [95% Conf.	Interval]
_treated	.6809524	.1159486	5.87	0.000	.4536972	.9082075
_cons	.3	.1189191	2.52	0.012	.0669228	.5330772

Table A.5, A.6, A.7 and A.8 show a positive and highly significant propensity scores for erosion control (3.4912 tons ha-1 yr-1) for the ATT and 2.089286 tons ha-1 yr-1 for the unmatched sample. The biodiversity indicator as deadwood reveals a score of .07143 for the average treatment effect of the treated and .6809524 for the unmatched sample. Again comparing the ATT and unmatched values show that the treated increased the likelihood of both erosion control and biodiversity conservation.

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Chapter 5

Paper 4: Multiple conceptualizations of nature are key to inclusivity and legitimacy in global environmental governance

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Multiple conceptualizations of nature are key to inclusivity and legitimacy in global environmental governance

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Highlights

- Different peoples and cultures live in, and interact with, nature in different ways;
- Stories, and the language we tell them in, are instrumental to envisioning nature;
- We examined diverse conceptualizations of nature in more than 60 languages;
- We identified three clusters: inclusive, non-inclusive and deifying “natures”;
- Acknowledging the diversity of nature conceptualizations is key to representative environmental governance;
- Diverse conceptualizations of nature provide a rich resource for informing environmental policy and future scenarios.

Abstract

Despite increasing scientific understanding of the global environmental crisis, we struggle to adopt the policies and practices science suggests we should. One of the reasons for this is the general absence of inclusive engagement and dialogue among a wide range of actors with distinct interactions with nature. Furthermore, there is little consideration of the role of language in understanding and shaping human-nature relations across different worldviews and cultures. In this paper, we propose that engagement and dialogue between the different actors involved in, or affected by, efforts to address the global environmental crisis can be strengthened by being mindful of the breadth of the diverse human-nature relations found around the globe. Examining diverse conceptualizations of “nature” in more than 60 languages, we find that conceptualisations of nature fall into three broad clusters: inclusive conceptualizations where humans are viewed as an integral component of nature; non-inclusive conceptualizations where humans are separate from nature; and deifying conceptualizations where nature is understood and experienced within a spiritual dimension.

Considering and respecting this rich repertoire for describing, thinking about and relating to nature can help us articulating global environmental governance in ways that resonate across cultures and worldviews. This repertoire also provides a resource we can draw on when defining policies, sustainability scenarios and practical interventions for the future thus offering opportunities for finding solutions to global environmental challenges, such as illustrated by the different laws granting legal personality to nature adopted around the world.

Keywords: Earth jurisprudence; Indigenous Peoples; knowledge systems; ontological turn; Rights of Nature; science-policy process

5.1 Introduction

Addressing global environmental challenges requires participation of, and successful dialogue and cooperation with a broad range of stakeholders, including academics, the private/business sector, policymakers, civil societies and local constituencies. The interventions needed to address these challenges are shaped by multiple knowledge systems and civic epistemologies (i.e. the formal and informal rules reflecting patterns of social, political and cultural practice) existing across the globe (van Kerkhoff and Pilbeam, 2017; Jasanoff, 2007). Appreciation of differences between languages, worldviews and cultures is essential to achieve meaningful dialogue and fruitful engagement in global environmental governance (Breslow et al., 2016; Costa et al., 2014; Ostrom, 2009; Welch et al., 2005). This position is reflected, for example, by the conceptual framework of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), stressing the importance of integrating a range of hetereogeneous worldviews and practices in relation to nature (Diaz et al., 2015a,b; Turnhout et al., 2012; Larigauderie et al., 2016; Reuter et al., 2016; Lambini et al., 2017). In this vein, IPBES is undertaking a methodological assessment on the diverse conceptualization of multiple values of nature and its benefits, including biodiversity and ecosystem services (IPBES, 2015; Pascual et al., 2017).

Different peoples and cultures live in and with nature in different ways. Cultural and environmental anthropologists have shown that there are many different ways of understanding nature and that these diverse conceptualizations have been shaped by different historical and cultural contexts (Descola and Gisli, 1996; Ellen and Fukui, 1996; Posey, 1999). The variety across conceptualisations of nature is reflected in different languages and in the many ways people from different cultures describe nature. Throughout history, specific conceptualizations of nature have been adopted over others, reflecting power struggles and influencing different approaches to the governance of nature (Escobar, 1998; Van Noordwijk et al., 2014). It has been argued recurrently that mobilizing different knowledge systems for environmental governance requires open channels of communication between different knowledge-holders (Cash et al., 2003; Fernández-Llamazares et al., 2015). Environmental governance from local to global levels can benefit from acknowledging the diversity of values that different worldviews offer, including the views of Indigenous and local knowledge-holders (Tengö et al., 2014; 2017; Nehuelhual et al., 2018). Key messages and policy options from science-policy assessments should stimulate the formulation of decision-making tools that better resonate across a wide range of cultural, epistemic and ontological contexts. The diversity of conceptualizations of nature across the world constitutes an important resource for envisioning multiple ways to govern human-nature relations to create sustainable futures.

Changes in how relationships between people and nature are viewed influence environmental science, policy and practice (Mace, 2014). Since the 1960s the dominant nature conservation practice has changed several times, from a tendency to treat people and nature as separate (“nature for itself” and “nature despite people” approach), to a way of thinking which recognizes the benefits of nature to humans (“nature for people” approach) (Mace, 2014; Schoolenberg et al., 2018). In common to most conservation framings, however, is an assumption that there is just one single concept of nature. This avoids the challenging task of bringing together different cultural understandings of nature, limiting opportunities for broader engagement in conservation projects. Investigating language and specifically, how it is used to describe and define nature across cultures is relevant to identify and distinguish important cultural differences in how nature is conceptualized globally.

In this paper we explore different conceptualizations of 'nature' in more than 60 languages, bringing together research in anthropology and the evolution of conservation science and practice. Building on this body of research and existing classifications, we identify three broad conceptual categories (i.e., inclusive natures, non-inclusive natures and deifying natures). We argue that global environmental governance can be strengthened by recognising fundamental differences and a greater plurality in how nature is conceptualized across different societies. Ensuring the integration of this diversity into policies and agreements could lead to more effective environmental policies with broader stakeholder engagement.

Our classification is intended to be adaptable to different interpretations. It constitutes a “map”, not necessarily restrictive but rather orientative, useful to understand the broad range of conceptualizations of nature co-existing in the world. It can be used as a basis for fruitful debate around promoting inclusivity and legitimacy of different knowledge systems and worldviews in environmental policymaking.

5.2 Nature is multiple and always in the making: language shapes, and is shaped by, human-nature relations.

Language has multiple dimensions, as within a single idiom multiple forms of language coexist in different cultural and social contexts, and language is flexible to different uses (e.g. technical or non-technical language). While a number of disciplines such as environmental history (Crosby, 2003), anthropology (Descola, 2006), cultural geography (Cosgrove, 1998) and, more directly, ecolinguistics (Haugen, 2001) recognize the role of language in shaping our perceptions of the world, this has received limited attention across environmental sciences as a whole to date (Döring and Zunino, 2014). While acknowledging that some practical environmental knowledge is non-linguistic, and make use of different means of representation such as actions, gestures, or scenic images (Lohmar, 2012; Benítez-Burraco and Moran, 2018), we argue that language is an interactive entitiy and process that forms an intrinsic part of human-nature relations. Languages are both shaped by the world around us and shape our patterns of actions: "*language is interconnected with the world; it both constructs and is constructed by it*" (Mühlhäusler, 2003). The multiplicity of languages around the world can be seen as emerging through a set of complex interlinkages with nature while at the same time structuring our relations with it.

Fischer (1984) suggests that the human species can be thought of as *Homo narrans*: human societies, relationships and sense of self are constructed through stories. For Okri (1996), "*stories are the secret reservoir of values: change the stories that individuals or nations live by, and you change the individuals and nations themselves*". Stories are articulations of our perceptions and legitimise and inspire our actions (Kuletz, 1998), so that the stories we (re)tell, and the language we use to do so, shape our view of the world and become the stories we live by, establishing the frames of reference through which we make sense of the roles, structures and relationships in the world (Stibbe, 2015; Lakoff, 2010). Words, terms, ideas, songs, images, and stories about nature have direct impacts on how nature is perceived and communicated (Satterfield and Slovic, 2004; Coscieme, 2015). Importantly, such stories also include the ones told by scientists (Latour, 2009).

The ecological implications of the stories we tell and the language we use to tell them have been explored in a growing body of ecolinguistics literature, spanning explorations of how grammar, specific words and overarching stories about human beings and the world in which we live contribute to construe reality (Alexander and Stibbe, 2014). Schultz (2001) shows how language to describe economic activities fails to highlight ecological aspects, such as when using 'land clearing' with a positive connotation, rather than a more accurate description such as 'native vegetation removal'. Rosenfeld (2019) discusses the ecological implications of the use of the words ‘weed’, when used to describe an undesirable plant, and ‘soil’, when used as a verb to describe defiling something or making it unclean. Kuletz (1998) explores how the term ‘wasteland’, defined as “an empty area of land, especially in or near a city, which is not used to grow crops or built on, or used in any way" is used to label permissible locations for storing nuclear waste.

Descriptions of the world as the dominion of human beings support human-nature relations that promote human welfare at the expense of other species (Martin et al., 2016). The "discovery" of America, as well as the stories told by European explorers and travellers about unhabitted distant lands, created 'new' continents, landscapes, peoples and 'nature' in ways that legitimated colonial appropriation (Spurr, 1993; Stepan, 2001; Strachan, 2002). Stories about the causes of deforestation and degradation of the Sahel influenced environmental policies in the 1970s and 1980s (Fairhead and Leach, 1996). Indigenous peoples' stories enact more intimate relations between humans and nature. For many Indigenous peoples across the Andes, *Pachamama*, is an active sentient being. For the Mowachat/Muchalaht First Nation, their deceased chief reincarnated in an orca whale that left her pod to stay closer to her people, thus opening a debate on if and how to intervene and relocate her (Blaser, 2013; 2014). Overall, practices building on the complex webs of relationality with nature and spiritual beings common in many Indigenous people knowledge systems result in different relations between nature and humans than the practices building on stories of Earth as being the dominion of human beings (De la Cadena, 2015).

Stories are intertwined in different ways with the languages that have emerged in close relation to the physical worlds of their speakers (Mülhäusler, 2003). Different languages may hold rich discourses that encode what their speakers have learned about living sustainably in the local environment. Scientific studies and environmental assessments describing local socio-ecological settings in terms and language foreign to the language spoken by local communities could misinterpret or misrepresent peoples' understandings of nature, and limit participation of non-English speaking knowledge-holders (Kovács and Pataki, 2016). Mülhäusler (2001) suggests that one of the principal reasons slowing down progresses in environmental sciences is monolingualism and monoculturalism, showing how the inclusion of different interpretations and languages is a requisite for solving global environmental challenges (see Goldman et al., 2018 for the case of climate change). Several authors have claimed that, given that different languages reflect different cultural understandings of nature, increasing linguistic diversity in the environmental sciences could help to broaden and diversify the values underpinning conservation practice (Niles and Tachimoto, 2018 ; Rosenfeld, 2019) and challenge hegemonic patterns of knowledge production (Meneghini and Packer, 2007 ; Tietze and Dick, 2012).

In sum, the stories we tell, the language we tell them in, and the words used to tell them are instrumental in the cultural production of nature and in shaping human-nature relations. These stories help us identify different communities that share a number of understandings about what does exist and how the natural, human and spiritual worlds are articulated (Mathez-Stiefel et al., 2007). When talking of stories about nature, we include those told by scientists and scholars through their research and publications. The impact of these stories will in part depend on the degree to which they resonate with other peoples' conceptualizations of nature, and the extent to which they resonate with the existing political narratives. Maximising the impact that stories have may entail crafting stories that respect and consider different views and understandings of nature (e.g., Green et al., 2015; Fernández-Llamazares & Cabeza, 2018). Furthermore, as stories are involved in creating realities, we need to be mindful that they can also reinforce unsustainable worlds (Blaser, 2014). Similarly, local languages and knowledges may hold important resources for imagining and implementing ecologically sustainable human-nature relations.

5.3 Exploring multiple natures through multiple languages.

To explore the multiplicity of different natures across the world and stimulate discussion we collected conceptualizations of ‘nature’ in different languages, accounting for more than 60% of the global population (Figure 5.1). By language we mean a system of communication used by the people of a particular country, region or community for writing and/or talking to each other. We excluded jargon mostly confined within specific disciplinary or technical contexts.

The methodology used is aligned with the methodology and results of similar excercises (e.g. Mace, 2014; Schoolenberg et al., 2018) and a vast body of cultural and environmental anthropology research; it consisted of the following steps: 1) researchers, practitioners and policymakers involved in the IPBES assessments were invited via email by the authors to write (in English or in their own language) an answer to the question (written in English): "how would you translate the word 'nature' in your language?" and elaborate on the meaning and use of the term (or terms) they indicated, with a particular focus on how it defines human-nature relationships; 2) responses were returned by 68 participants covering a total of 63 different languages; 3) following an inductive coding approach (e.g. Kelly et al., 2007) the responses were read by the authors, and a discussion on commonalities among the different terms emerging from the responses was held; 4) the authors developed tentative categories and the terms indicated by the respondents were placed within one of the categories; 5) the premilinary results of the analysis as well as the category in which each conceptualization belonged were shared with the respondents and, 6) a space for debate and dialogue on the results of the analysis and their implications for policymaking was provided for the authors and the respondents via email exchange to reach a shared agreement on the conclusions.

The responses reflect individual interpretations and uses of the terms. An informed human consent form was sent to the participants explaining the purposes of the study and mentioning that participation was voluntary and individual responses will remain confidential and data will be used for research purposes. All of the responses and further inputs have been equally considered and equal space and opportunities for participation was given to each of the respondents. The authors are a mix of interdisciplinary researchers and policymakers who are native speakers of more than two thirds of the languages represented in the survey.

Three broad and possibly overlapping categories (Figure 5.1) emerged from our analysis: 1) Inclusive (i.e., human beings are an integral part of nature); 2) Non-inclusive (i.e., human beings are not an integral part of nature, implying some sort of human-nature dichotomy); and 3) Deifying (i.e., nature is defined within a spiritual realm).

Through the analysis, we aim to illustrate the considerable breadth and depth of the multiple conceptualizations of nature that exist, and to use this as an entrypoint to reflect on the importance of being mindful of the multiple ways of relating to and governing nature (Díaz et al., 2018). We recognize that the three categories that emerged from the responses and through sharing our analysis with the respondents do not represent all possible categories that could be derived. These categories emerge from a debate among the authors and the respondents and thus represent one of many possible ways of interpreting our results. Furthermore, the inclusion of a conceptualization in a specific category should not be understood in a strict sense. In other words, we do not imply that inclusiveness (of humans in nature) and a spiritual dimension can be precisely quantified to a certain degree, but we do recognize that a continuum exists along these dimensions. Indeed, a fourth 'category' was deemed necessary to capture conceptualizations that are not entirely and unequivocally relatable to any of the other three Figure 5.1. These conceptualizations can assume, to a larger degree, a more inclusive or non-inclusive connotation and a spiritual dimension, depending on the context of use and the individual perspective.

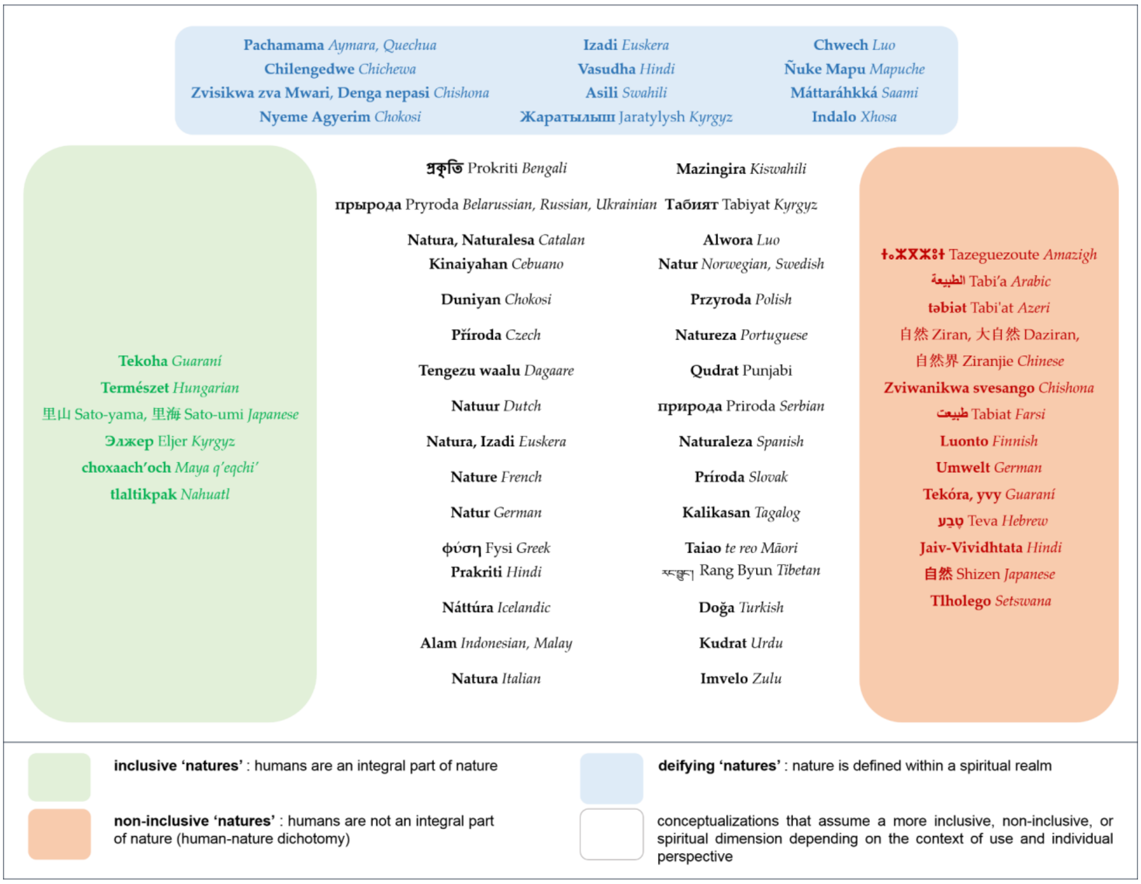

Figure 5.1 Multiple conceptualizations of nature: non-inclusive, inclusive and deifying.
Different conceptualizations are understood along a continuum from non-inclusive natures that mostly exclude humans from the concept of nature, to inclusive natures that include humans. Deifying natures equate nature to the act of one or multiple deities. Some conceptualizations can be used with different degrees of inclusiveness, and assume a spiritual connotation, depending on the context and individual interpretations.

Inclusive conceptulizations of nature present human beings and their systems (e.g., cities and farms) as part of nature (Figure 5.1). This is the case of the Dagaare (Ghana) term *Tengezu waalu* that refers to 'all the living and non-living things' and also of the Hungarian word *Természet*, a conceptualization of nature that literally means 'everything'. Even more specific in this vein is the Kyrgyz term Элжер [Eljer], referring to 'people and the land', thus characterizing humans as a natural component integrated within nature, i.e. together with the land.

Inclusive conceptualizations of nature feature prominently in many Indigenous languages (Atleo, 2011; Kohn, 2013; Porter, 2014; Zent, 2015). For example, Indigenous ontologies in Latin America move away from the representation of an abstract and universal nature towards recognition of 'Earth beings' as animate manifestations of nature (De La Cadena, 2010). Similarly, the concept of *iwigara* of the Raramuri peoples of Mexico refers to the total connectedness of all life and entails a view of nature as relatives sharing space (Salmón, 2000).

Importantly, the link between Indigenous conceptualizations and inclusive practices are reflected in the remarkable overlap between Indigenous territories and the world's remaining areas of high biodiversity (Sheil et al., 2015; Schuster et al., 2018; Bertzky et al., 2012; Garnett et al., 2018).

Non-inclusive natures exclude human beings implicitly or explicitly from what is considered as nature, implying some sort of nature-culture dichotomy (Figure 5.1). In non-inclusive natures, humans are considered as clearly distinct from the rest of the natural world. Examples of this distinction come from the Chinese language, in which the concept of nature can be expressed as 自然 [Ziran], i.e. 'natural', referring to pristine or untouched environment. Similarly 大自然 [Daziran], i.e. 'big natural', refers to everything not made by humans, and 自然界 [Ziranjie], i.e. 'natural world', refers to everything non-human.

In Japanese the term 自然 [Shizen] uses the same characters, although pronounced differently, as the Chinese 'Ziran', also referring to pristine, or unmodified environment in which humans evolved. However, more specifically, 'Shizen' conceptualizes nature as superior to and beyond human control, sometimes causing the destruction of human society, e.g. earthquakes, tsunamis, volcanic eruptions, storms and typhoons. As the importance of production landscapes and seascapes has become recognized in the nature conservation discourse in Japan, the word 里山 [Sato-yama] or the word 里海 [Sato-umi] have become frequently used. They imply a more inclusive connotation of nature referring to landscapes where reciprocally beneficial relationships between nature and people exist.

In 'deifying' conceptualizations of nature, nature is perceived as a Goddess or a God. Many cultures further distinguish between understandings of nature as something created (or donated) by a deity, and god or gods that are the very personification of nature (Figure 5.1). The latter is the case of *Vasudha*, i.e., 'Mother Earth', in Bengali (Hindi), or the Quechua and Aymara *Pachamama*, or the Mapuche *Ñuke Mapu*. Nature is conceptualized as 'God´s gift', *Nyeme Akyerem*, in Chokosi (Ghana), with humans as receivers of the gift. References to nature as the result of God´s creation are found in many cultures: the Chewa (Malawi) *Chilengedwe* (the Creation), the Shona (Zimbabwe) *Zvisikwa zva Mwari* (God´s Creation), the Xhosa *Indalo* (the Creation, excluding humans) and *Denga nepasi* (Heaven and Earth), the Kyrgyz Жаратылыш [Jaratylysh] (everything that was created), the Luo (Kenya) *Chwech* (the Creation). Many of these conceptualizations have a holistic character, encompassing non-human living organisms, ancestors, deities and their intertwined histories (e.g., Berkes, 1999; Descola, 2006).

Deifying conceptualizations of nature could assume an inclusive or non-inclusive worldview in different cultures and contexts of use. This implies that a spiritual understanding of nature shares attributes and values with non-spiritual conceptualizations of it. For example, the biblical understanding of animals and plants as made for the use of human beings might better resonate with non-inclusive conceptualizations of nature, reinforcing the vision of humans as stewards of nature. On a different level, in South Asia and especially in India, nature is sacred and present in daily practices (Guha, 2014). The religious and spiritual values in the culture of *Ahimsa* (*to live and let live*) are shaped by how humans treat nature (Habib, 2010). Elephants are revered as a god (Ganesh baba), and vultures are sacred for excarnation among Zoroastrians. Sarus cranes are symbols of marital fidelity, and this intimate inclusion of nature into religious and spiritual values have helped the conservation of this species. Overall, "*India's unity as a nation has been firmly constituted by the sacred geography it has held in common and revered"*, and this worldview "*continues to anchor millions of people in the imagined landscape of their country*" (Eck, 2012).

In some cases, the concept of nature is directly linked to specific environments. This is the case of the Shona (Zimbabwe) *Zviwanikwa svesango*, a conceptualization of nature that refers to forest resources/biodiversity. Another example is the Amazigh ⵜⴰⵣⴳⵣⵓⵜ [Tazeguezoute], meaning 'greenery', which evokes environments with a specific 'chromatic' connotation.

Many conceptualizations of nature have been lost over time. This is particularly the case for languages that suffered a decline in use, especially when Indigenous and local languages have been replaced by non-native languages in the formal education system (Amano et al., 2014; Harmon and Maffi, 2002; Moseley, 2010; Stepp et al., 2004). Languages that emerged from the fusion of multiple languages out of necessity for goods trade, slave trade, or other historical conditions (e.g., *creole, patua, swahili*) tend to refer to simplified and utilitarian conceptualizations of nature. For example, in Swahili, nature as a stand-alone term is non-existent although it tends to be translated literally as 'original' (*asili*) with connotations of 'unaltered by humans', i.e. 'natural' or 'environment' (*mazingira*). In the absence of a single term that captures the idea of a space that is 'natural', Swahili speakers use an unofficial Swahili version of the English word 'nature' (*necha*) in everyday verabal communication.

5.4 Implications for policy development.

Policy can be conceived as the institutionalization of behaviours and socially accepted practices (Clark, 2002; Game et al., 2015). Policies express societal moments, including how nature is perceived, understood and used in discourses by society in a particular time and context. Different conceptualizations of nature reflect different behaviours and practices and have laid the ground for different policy approaches towards nature conservation and environmental governance. Here, we discuss how the three conceptualizations of nature we present are often related with specific conservation approaches.

For instance, laws promoting the recognition of the Rights of Nature have been, in most cases, heavily influenced by Indigenous Peoples' philosophies which place nature at the center of all life (Akchurin, 2015; Borràs, 2016). The Bolivian Law of Mother Earth (Law 071; 21st December 2010; Gaceta Oficial del Estado Plurinacional de Bolivia) draws on Andean spiritual traditions seeing Mother Earth (or Pachamama) as a sacred deity, and entitles nature with rights as a collective subject of interest (Pacheco, 2014; Kauffman & Martin, 2016). In addition to defining a set of morals for environmental governance, the Law of Mother Earth aims at preventing "human activities causing the extinction of living populations, the alterations of the cycles and processes that ensure life, or the destruction of livelihoods, including cultural systems that are part of Mother Earth" (Article 8); while people, and public and private legal entities, have the duty to "uphold and respect the rights of Mother Earth" (Article 9) (Humphreys, 2017). Similarly, by granting legal status to the Whanganui River, New Zealand found an innovative way to honour and respect the Māori traditional worldview of nature as "an indivisible and living whole" (Hutchinson, 2014; Strack, 2017). However, initiatives for promoting Rights of Nature do not always stem from indigenous philosophies, such is the case of the recognition of legal rights to the Amazon River by the Supreme Court of Colombia (see Chapron et al., 2019 for this and further examples). Nevertheless, the question of how to define nature is fundamental to effectively implementing its legal rights (Pascual et al., 2017). Successful expansion and implementation of the Rights of Nature will depend on the ability of legal systems to integrate new ways of conceptualizing what nature is in different cultural contexts (Fahrenkamp-Uppenbrink, 2019).

In contexts where multiple conceptualizations of nature co-exist, as would be the case in global environmental negotiations, policies should be designed to construct an integrated discourse and set of practices, from a view of 'multiple cultures associated to a single nature' to a new view of 'multiple natures related with multiple cultures'. Since language is one of the main cultural instruments, the challenge for policymakers (as well as natural scientists) is to implement initiatives and communicate their knowledge to different cultures and in different languages. For example, the contextualized application of initiatives such as the Earth Charter in Guatemala with Maya-Q´eqchi´ Indigenous communities integrates values and other aspects inherent to the Mayan worldview where balance, respect and reciprocity with the Earth and the cosmos are central to strengthen an environmental-cultural educational process. The Earth Charter principles were translated in Maya-Q´eqchi´ to students and teachers highlighting the links between these global values and their local context. From this initiative, numerous other voluntary conservation initiatives have emerged in educational centers, such as community reforestation trainings, cleaning campaigns of water bodies, recycling and sustainable consumption campaigns, as well as the definition of an environmental policy for solid waste management (Meda & Hermes, 2014). In a broader sense, initatives such as the Earth Charter could be the basis for developing hubs for participatory policymaking with the aim of bringing in perspectives from multiple ethnicities and indigenous worldviews to the policy discourse.

The notion of inclusive nature implies in many instances a more equal and integrated conception of the value of human beings and nature, and often expands the frontiers of who is entitled to have specific rights, including a broad range of non-human beings such as animals, plants, or entire ecosystems. The Satoyama Initiative recognizes the notion of reciprocity with nature, integrating conservation and the sustainable use of biodiversity in production landscapes (Takeuchi, 2010). Similarly, biocultural approaches to conservation reflect the co-evolutionary dynamics of interdependent social-ecological systems (e.g. Gavin et al., 2015, 2018; Buizer et al., 2016; Sterling et al., 2017; Fernández-Llamazares and Cabeza, 2018).

Many Indigenous communities in the Amazon Basin conceptualize nature as a continuum where all lifeforms (humans and non-humans) are inter-connected (Viveiros de Castro, 1998; Descola, 2006). As such, in these communities, nature is often governed and managed through principles of relationality, which are often intended as the mutual interdepence of all that exists (Århem 2003; Gambon & Rist 2019). Sustainability is therefore understood through its focus on maintaining reciprocal relations with nature over time (Virtanen et al., 2012; Comberti et al., 2015).

In contrast, in cultural contexts with non-inclusive natures, a nature-culture divide is often enshrined in nature conservation legislation. ‘Fortress conservation’ measures and strict Protected Areas are perhaps the most paradigmatic examples in this vein (Brockington, 2002; Siurua, 2006; De Santo et al., 2011). Policy debates around ‘land sharing’ and ‘land sparing’ (e.g., Phalan et al., 2011, 2016; Balmford et al., 2018; Lamb et al., 2016) or around the ‘Nature Needs Half’ Initiative (e.g., Noss et al., 2012; Wuerthner et al., 2015; Wilson, 2016) further reflect the epistemological tensions that emerge when equating nature with wilderness (Fischer et al., 2014; Büscher et al., 2017).

Customary institutions of Indigenous Peoples often recognise the deep connections between nature and people in a more integrated manner (Parotta and Trosper, 2012; Chen and Gilmore, 2015) based on relational values (Jeeva et al., 2006; Clark and Slocombe, 2009; Samakov and Berkes, 2017), kinship-oriented philosophies (Salmón, 2000; Bird, 2011; Aniah & Yelfaanibe, 2016) and a powerful stewardship ethics (Gammage, 2011; Kohn, 2013). The strong existing overlap between Indigenous territories and biodiversity hotspots (Gorenflo et al., 2018; Garnett et al., 2018) suggests that we may find inspirations from Indigenous knowledge systems for new stories about nature, envisioning new ways for achieving human well-being while halting biodiversity decline. Investments in the development of measures and assessments of the level of integration and participation of Indigenous and local communities (e.g., Aichi Target 18) remains an urgent priority for environmental policymaking (Tittensor et al., 2014; Reyes-García et al., 2019). Broad inclusion will bring legitimacy to conservation and other environmental policies, assisting policymakers in avoding too narrow representations of the overwhelming diversity of human-nature relations.

Successfully addressing global environmental challenges requires broadening sustainability imaginaries and co-designing policies and policy instruments that are more respectful and inclusive of different worldviews. This implies acknowledging nature in its full diversity, including the spectrum of relationships by which humans relate to nature (Diaz et al., 2018). Doing so can promote values around which different interpretations of nature and human-nature relationships can co-exist. This does not necessarily imply reaching consensus amongst different knowledge-holders, but serves as a basis for conversation, stressing the complementarity and the flexibility of the diverse conceptualizations of nature (Dunkley et al., 2018). The consideration of multiple visions and concepts of nature, stemming from heterogeneous worldviews and epistemic and philosophical traditions, can be achieved through mobilizing knowledge in support of culturally-sensitive initiatives for global environmental governance. For example, the IPBES fellowship programme (IPBES, 2019) brings together early-career researchers and practitioners from multiple disciplines and cultural contexts, including Indigenous People, supporting the authors of the assessments with the aim of including multiple conceptualizations of nature, as well as an intergenerational and multidisciplinary dimension, for addressing and halting global decline in biodiversity and ecosystem services. Similarly, the International Union for Conservation of Nature (IUCN)

World Commission on Protected Areas (WCPA) Capacity Development Initiative (Appleton, 2016) aims at improving the capacities of individuals and organisations involved in the management of protected areas, including initiatives by, for and among Indigenous Peoples on the implementation of traditional knowledge. The International Institute for Environment and Development (IIED) is exploring through participatory action-research how the biocultural heritage of different Indigenous communities in China, India, Kenya and Peru can contribute to climate change adaptation by promoting agrobiodiversity conservation, sustainable livelihoods and secure land rights. Some of the objectives of this project are establishing biocultural heritage territories and develop a global brand for biocultural products and services, supported by Indigenous labelling and certification (IIED, 2019).

Nature is experienced, represented and conceptualized in a myriad of ways (Niles & Tachimoto, 2018). This influences the choice of the tools we use to study it (both qualitative and quantitative), how we bring it into policy and ultimately how we will (or not) be its stewards. Practical field guides to participatory and other research tools such as the ARPNet Dilly Bag used by Aboriginal research practitioners in Australia (Sithole, 2012) are good examples to replicate and implement for improving communications with other cultures, learn about their conceptualization of nature and consider these in policy initiatives. The inspiration that multiple stories, practices, values and worldviews can bring for envisioning futures is explored in future scenarios making and modelling projects such as the Seeds of Good Anthropocene (Bennett et al., 2016) and the IPBES Assessment on Scenario and Models of Biodiversity and Ecosystem Services (IPBES, 2016; Pereira et al., 2019). These examples demonstrate how multiple knowledge systems and conceptualizations of nature and human-nature relations, captured through participatory processes and community engagement, contribute to shaping worldviews on the future, with the potential of informing and driving decision-making (Rosa et al., 2017).

5.5 Conclusions

Beyond reflecting the beautiful and rich variety of human relationships with nature and being one fundamental aspect of humans' collective knowledge of the world, different conceptualizations of nature influence behavior and actions at individual, institutional and societal levels. Understanding how other people perceive nature opens a space for deliberation and participation while offering new options and tools for cooperation to address environmental challenges.

We have presented how nature is understood in different languages as belonging to either inclusive, non-inclusive or deifying conceptualizations of nature. The examples we provide of the uses of different conceptualizations of nature for environmental governance make us conclude that global environmental decision-making should include a comprehensive discussion of, and dialogue among, multiple conceptualizations of nature and engage a diverse pool of inter- and transdisciplinary scientists from as many different countries and cultures as possible, including Indigenous Peoples, local communities and other underrepresented groups. In addressing different conceptualizations of nature we will enhance our ability to tell, hear and learn from, stories that resonate across cultural, social and political boundaries. Such stories will extend the outreach of international research initiatives by broadening the scope and significance of the results, strengthening impacts and communicability towards a range of people and policymakers around the world.

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Chapter 6

Paper 5: Strengths, Weaknesses, Opportunities and Threats: a SWOT analysis of the ecosystem services framework

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Strengths, Weaknesses, Opportunities and Threats: A SWOT analysis of the ecosystem services framework

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A B S T R A C T

The ecosystem services concept (ES) is becoming a cornerstone of contemporary sustainability thought. Challenges with this concept and its applications are well documented, but have not yet been systematically assessed alongside strengths and external factors that influence uptake. Such an assessment could form the basis for improving ES thinking, further embedding it into environmental decisions and management.

The Young Ecosystem Services Specialists (YESS) completed a Strengths–Weaknesses–Opportunities–Threats (SWOT) analysis of ES through YESS member surveys. Strengths include the approach being interdisciplinary, and a useful communication tool. Weaknesses include an incomplete scientific basis, frameworks being inconsistently applied, and accounting for nature's intrinsic value. Opportunities include alignment with existing policies and established methodologies, and increasing environmental awareness. Threats include resistance to change, and difficulty with interdisciplinary collaboration. Consideration of SWOT themes suggested five strategic areas for developing and implementing ES.

The ES concept could improve decision-making related to natural resource use, and interpretation of the complexities of human-nature interactions. It is contradictory – valued as a simple means of communicating the importance of conservation, whilst also considered an oversimplification characterised by ambiguous language. Nonetheless, given sufficient funding and political will, the ES framework could facilitate interdisciplinary research, ensuring decision-making that supports sustainable development.

1. Introduction

The term 'ecosystem services' (ES) was first introduced in the 1980s as an advocacy tool for biodiversity conservation, and has since been subjected to a variety of definitions and classifications

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Highlights

- We completed a SWOT analysis of the ecosystem services (ES) framework
- The ES approach is a useful interdisciplinary communication tool
- Implementation is hampered by incomplete science and inconsistent application
- The ES approach could benefit from more alignment with existing policies and tools
- Threats include insufficient funding and a loss of political will
- We discuss strategies in light of the SWOT for furthering the approach

Abstract

The ecosystem services concept (ES) is becoming a cornerstone of contemporary sustainability thought. Challenges with this concept and its applications are well documented, but have not yet been systematically assessed alongside strengths and external factors that influence uptake. Such an assessment could form the basis for improving ES thinking, further embedding it into environmental decisions and management.

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Keywords: Earth jurisprudence; Indigenous Peoples; knowledge systems; ontological turn; Rights of Nature; science-policy process

6.1 Introduction

The term 'ecosystem services' (ES) was first introduced in the 1980s as an advocacy tool for biodiversity conservation, and has since been subjected to a variety of definitions and classifications (Ehrlich & Ehrlich, 1981; Ehrlich & Mooney, 1983; Chan et al., 2007; Peterson et al., 2010). Since the 1990s, the continued evolution of ecosystem service definitions and classifications has been well documented (e.g. Costanza et al., 1997; Daily, 1997; MEA, 2005; Boyd & Banzhaf, 2007; Wallace, 2007; Chapman, 2008; Costanza, 2008; Fisher et al., 2009; TEEB, 2010; Böhnke-Henrichs et al., 2013). Whilst there is no one universal ecosystem services definition or framework, a recent and widely cited definition considers ES to be "the direct and indirect contributions of ecosystems to human well-being" (Braat & de Groot, 2012; TEEB, 2012; Figure 6.1). Whilst critical voices have considered this a reflection of a utilitarian and anthropocentric view of nature, others emphasise that the concept of ES implies a worldview that humanity must be treated as part of nature rather than separate from it, and that we fundamentally rely upon functioning ecosystems – a view that has become increasingly recognised in recent decades (Mace, 2014). For the purposes of this paper, we define an ES framework to be "a framework by which ecosystem services are integrated into public and private decision making" (Ranganathan et al., 2008).

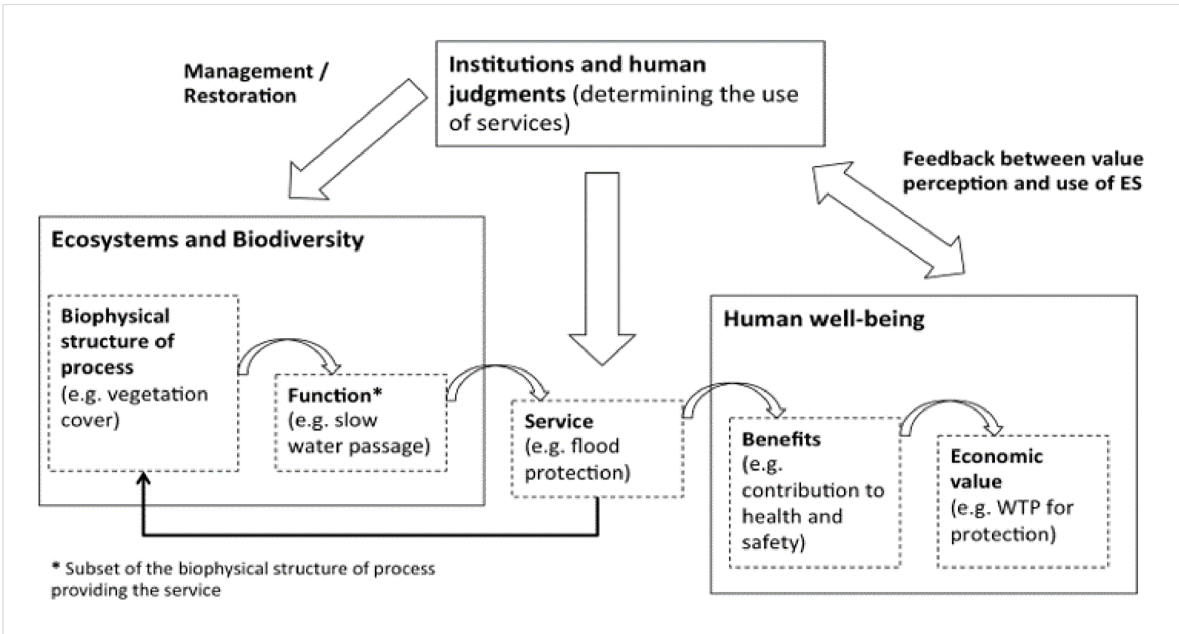


Figure 6.1 Schematic representation of the conceptual thinking behind the ecosystem services framework

(modified from: Braat & de Groot, 2012).

Such an approach can include valuation of the goods and services provided by nature to society, thus enabling them to be incorporated into decisions regarding the governance of natural resources (Daily et al., 2000; Yousefpour et al., 2012). An ES framework is not restricted to economic valuation, and also allows the integration of multiple value domains (ecological, social, cultural and economic values), thus acknowledging the complexity of social-ecological systems in decision making (Martín-López et al., 2014) and the plurality of human values (Kenter et al., 2015).

Although the academic literature continues to debate the definition of ES, decision makers have increasingly implemented ES as part of environmental and natural resource policies and management frameworks. However, the viability of the ES framework has been challenged both conceptually and practically (McCauley, 2006; Redford & Adams, 2009; Norgaard, 2010; Peterson et al., 2010; Barbier, 2012; Beaudoin & Pendleton, 2012 Ressurreicao et al., 2012; Sitas et al., 2014). A recent review by Schröter et al., (2014) highlights that the conceptual basis for ES may conflict with: biodiversity conservation; a fear of 'selling out' on nature; the commodification of nature; the vagueness of the concept; and, the power dynamics involved in ES research and management (see also Naidoo et al., 2008; Bullock et al., 2011; Sommerville et al., 2011). Knowledge gaps, specific to the connectivity between sustainability and human well-being, have also been highlighted as a challenge for the successful implementation of the ES concept (Nicholson et al.,2009; Chan et al., 2012), as have problems with existing tools, datasets and frameworks (Naidoo et al.,2008; Keeler et al., 2012). In light of these concerns and challenges, significant research investment continues to seek the 'best' implementation pathways for the ES concept (Kremen & Ostfeld, 2005; Carpenter et al., 2009; Petz et al., 2012). As part of a collective endeavour to better understand how to operationalize the ES concept, an increasingly wide variety of implementation frameworks (Cowling et al., 2008; Nahlik et al., 2012; Petz & van Oudenhoven, 2012), payment structures (Gibbons et al., 2011; Sommerville et al., 2011; Bryan, 2013), ES tools (Nelson & Daily, 2010), and datasets (Schulp et al., 2012; Baral et al., 2013) have been developed and trialled globally.

Paralleling the proliferation of these disparate approaches, and despite concerns from some regarding the extent to which the ES concept can realistically deliver upon its objectives (e.g. Norgaard, 2010), the concept has begun to inform an increasingly wide range of national and international legislation and agreements (Perrings et al., 2010). Examples include the ecosystem-based management on which the European Marine Strategy Framework Directive is built (Long, 2011; Jobstvogt et al., 2014), the 14 Aichi Targets developed by the Convention on Biological Diversity (Strategic Goal D; CBD, 2010) and incorporation of ES in the CBD Ecosystem Approach, as well as the relatively new Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES; Larigauderie, Mooney 2010). Given the landscape of conceptual and intellectual debates, practical concerns, and increasing legislative consideration, it is important to continually and critically appraise the ES concept – searching for gaps, suggesting how any gaps might be filled, and considering to what extent the approach remains fit for purpose in a wider context. Here, we look critically at the ES concept through a Strengths-Weaknesses- Opportunities-Threats (SWOT) type analysis. Existing reviews have explored challenges to the successful implementation of the ES concept (Wallace, 2007; de Groot et al., 2010). Our SWOT assessment presents these challenges in a broader context – by providing an integrated, structured analysis of perceived strengths and weaknesses within the ES concept and its applications, as well as of the external opportunities and threats that may benefit or impede further development. Additionally, we use such analyses to begin developing strategies that might overcome existing or future challenges to the ES concept. For the purposes of this paper, the authors surveyed an interdisciplinary group of ES researchers and practitioners – the Young Ecosystem Services Specialists (Böhnke-Henrichs et al., 2014) – eliciting their perceptions on the Strengths, Weaknesses, Opportunities and Threats of applying the ES concept for natural resource policy, planning, governance and management. YESS members are diverse, working across a wide range of ecosystems and disciplines, applying a variety of different methods and approaches to study and implement the ES concept (Böhnke-Henrichs et al., 2014). The rationale for relying upon early career ES researchers was to capture the perspectives of those who have a substantial, up-to-date understanding of the topic, but joined the field of ES research and implementation after its inception rather than being amongst those who first established it. Such researchers and practitioners are likely to critically think about established concepts, have cutting-edge experience of research on and implementation of the ES framework, and be actively engaged in innovation.

6.2 Material and Methods

A mixed methods research strategy (Teddlie & Tashakkori, 2011) was employed, in the form of online surveys and face-to-face discussion groups, so as to elicit the perceptions from YESS members on the Strengths, Weaknesses, Opportunities and Threats of the ES framework. Applying a mixed methods approach allowed researchers to better capture the richness and complexities of the phenomena under study than by using a singularly qualitative or quantitative approach.

6.2.1 Survey respondents

Young Ecosystem Services Specialists (YESS) is an international network of early career doctoral and postdoctoral researchers, lecturers, and practitioners working on a variety of ES topics at a range of research, environmental and nature conservation organisations. At the time of the SWOT analysis, there were 67 active members of YESS. As members represent a range of expertise in the ES field, they were considered sufficiently well informed to complete a SWOT analysis of the ES framework. Respondents' backgrounds span the natural sciences and environmental and ecological economics, but other social sciences were under-represented and there was no participation from arts or humanities scholars. As such, the sample is not representative of the whole early career ES research community.

6.2.2 SWOT analysis and development of strategies

SWOT analyses derive their name from the assessment of the Strengths (S), Weaknesses (W), Opportunities (O), and Threats (T) faced by an industry, sector, company or any organisation (Gao and Peng, 2011). The idea of a SWOT analysis has its roots in strategic management research conducted in the 1960s and 1970s (Sevkli et al., 2012), and arises from the perspective that the performance of a given (typically economic) agent with respect to a particular objective depends upon the way in which the management of that agent interacts with both the internal characteristics of the agent, and the broader external context in which the agent must act (but over which the agent has no direct control in the short term) (Houben et al., 1999). When applied to ES and its associated research fields, Strengths can be considered to be those features of the ES concept that underpin the ability of the concept and the field to achieve the implicit goals of: a) increasing awareness of the extent to which human societies interact with and are dependent upon the environment; b) better integrating the natural and social sciences and engaging and acknowledging stakeholder knowledge; c) greater understanding of the impacts of environmental change and environmental policy on human wellbeing; and, d) contributing towards achievement of sustainable relationships between human society and ecosystems. By way of contrast, Weaknesses are attributes that can undermine the achievement of the goals (a–d) unless they are specifically addressed and improved. Here, Strengths and Weaknesses can be considered features of the ES concept itself, or 'internal' features. Conversely, Opportunities include the economic, technical, social, political, legal, and environmental features representing the context within which the ES concept is implemented, and that may facilitate or encourage the achievement of these goals. We thus consider Opportunities to be 'external' features. Threats are, similarly, external features that may prevent the accomplishment of the above goals (a–d). The value of a SWOT analysis stems not only from its ability to highlight ways in which an agent's internal and external environments interact to affect its success (Houben et al., 1999), but also from its ability to be used in the development and implementation of long-term strategies to achieve particular objectives (Houben et al., 1999; Arslan and Er, 2008; Gao and Peng, 2011; Sevkli et al., 2012). There are various classes of strategies that can follow from a SWOT analysis: e.g. those that link Strengths and Opportunities ('SO Strategies'), those that link Weaknesses and Opportunities ('WO Strategies'), those that jointly focus on the Strengths and Threats ('ST strategies'), and those that arise from the joint assessment of Weaknesses and Threats ('WT Strategies'). For example, SO strategies utilise the fact that Strengths may help to capitalise upon external Opportunities, whereas WO strategies focus upon the pursuit of external Opportunities to lessen the severity of Weaknesses. Similarly, ST strategies focus on the potential for existing internal Strengths to mitigate the impact of external Threats, while WT strategies consist of actions intended to reduce both internal Weaknesses and external Threats simultaneously (Sevkli et al., 2012).

6.2.3 Analytical procedure

In conducting a SWOT analysis of the ES framework, an iterative approach was used. The first step of the process involved an online pilot survey (Survey 1) of 20 YESS network members, who were simply asked to share their perceptions about the Strengths, Weaknesses, Opportunities, and Threats (SWOT) of applying the ES framework in their work, as an open question. The pilot study was followed by two main surveys (i.e. Survey 2 and 3), where the framing of survey questions was refined based on pilot survey findings. The surveys took place in 2013: the pilot survey from January to March, Survey 2 from August to September, and Survey 3 from November to December. A central research coordinator compiled the responses from the pilot survey, and attempted to identify themes for each SWOT characteristic, including the frequency with which the theme emerged.

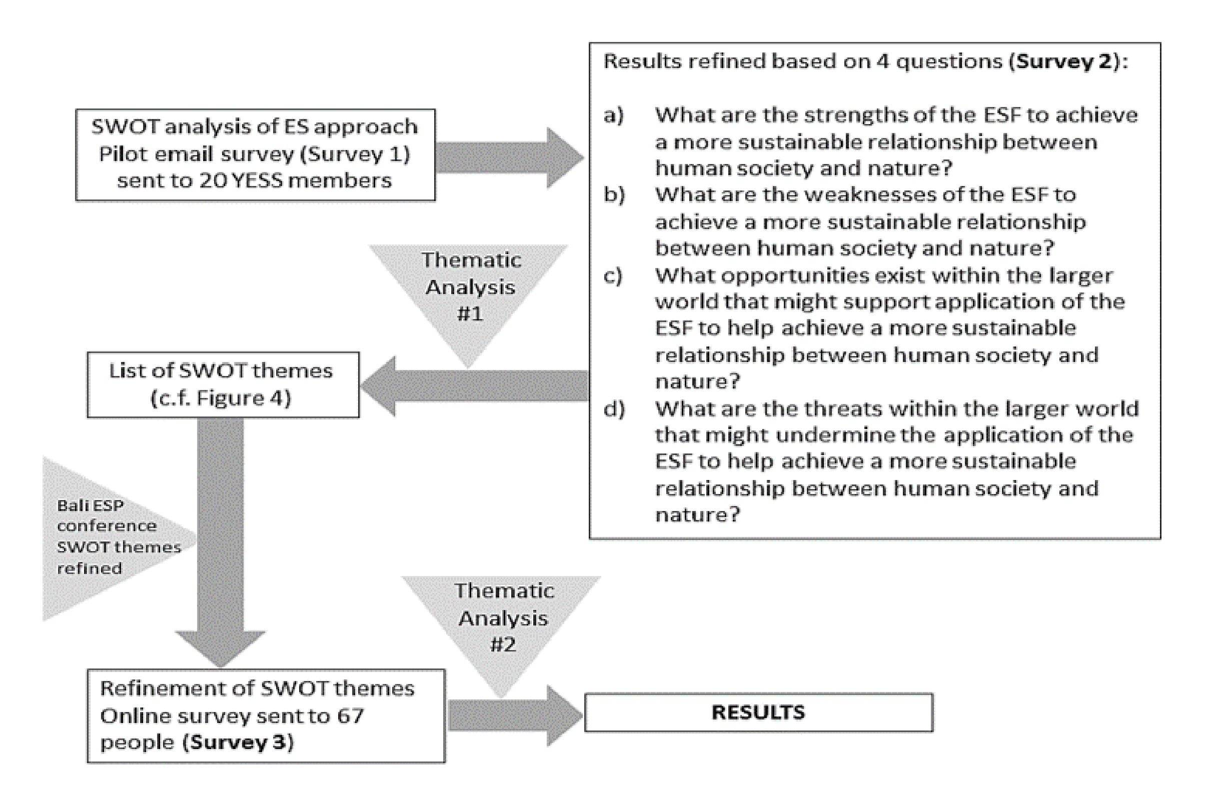


Figure 6.2 The development and delivery of the ES SWOT research process

The results of the pilot survey generated varied responses and fragmented agreement for each SWOT category – thus, the outcomes were sent back to YESS members, who were asked to refine their responses based on the following, more structured questions (Survey 2), and considering the goals (a–d) outlined in Section 2.2: Figure 6.2. a) What are the Strengths of the ES framework to achieve a more sustainable relationship between human society and nature? b) What are the Weaknesses of the ES framework to achieve a more sustainable relationship between human society and nature? c) What Opportunities exist within the larger world that might support application of the ES framework to help achieve a more sustainable relationship between human society and nature? d) What are the Threats within the larger world that might undermine the application of the ES framework to help achieve a more sustainable relationship between human society and nature?

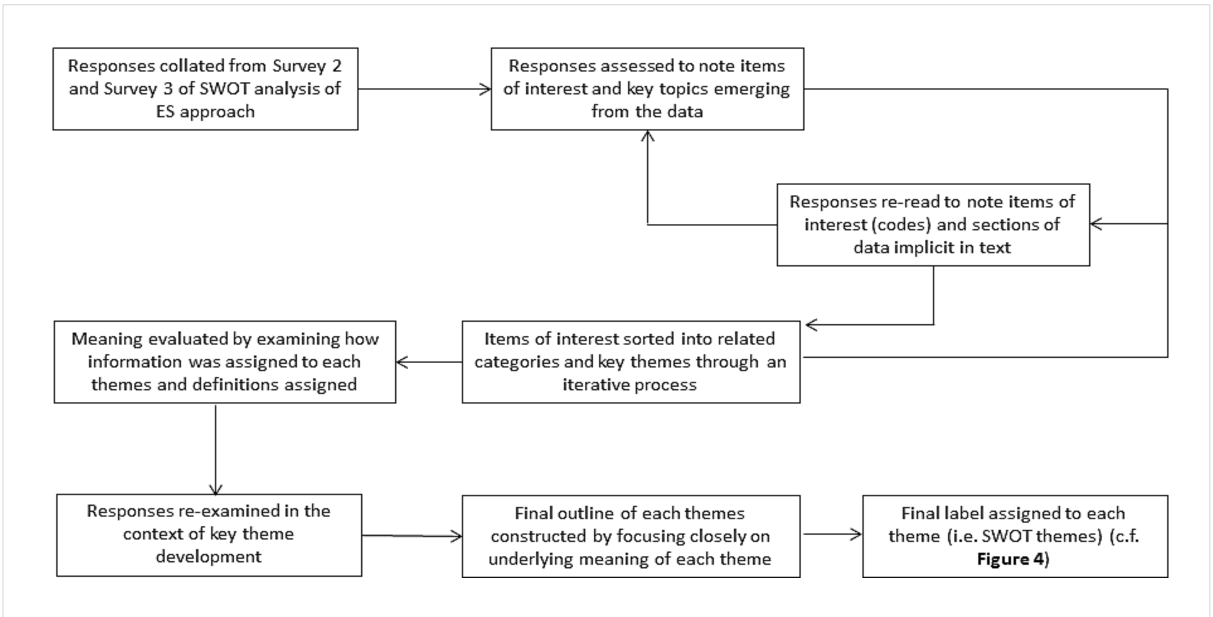


Figure 6.3 The analytical process performed upon responses to Surveys 1 & 2, to develop SWOT themes

A thematic analysis was carried out on the results of Survey 2 by two independent YESS researchers (Figure 6.3). 'Themes' were considered to arise if similar suggestions were made by more than one respondent (e.g. 'the ES framework is interdisciplinary', as a Strength). The researchers identified between 10 and 13 themes per SWOT category with the requirement that both researchers had to reach consensus on the existence and wording of each each theme. The results of that stage were presented, discussed and refined at the Ecosystem Services Partnership (ESP) conference in Bali in 2013[1], during a facilitated YESS workshop. Themes in all four SWOT categories were presented and explored in open discussion. Note that themes were not removed or added at this stage, as the goal was not to change the outcomes of the original survey; rather, their meaning was clarified as far as possible for a wider audience.

Following this refinement, a third online survey (Survey 3, Appendix) was developed and a link sent to all YESS members. Survey 3 required respondents to share their level of agreement on a 9-point scale from-4 ("strongly disagree") to +4 ("strongly agree") for each theme identified in the previous stage by the research coordinators, and refined at the Bali conference. 'Level of agreement' was then meas red between 0% and 100%, corresponding to the percentage of respondents that agreed with the theme (i.e. rating on the agreement scale between +1 to +4) or disagreed with the theme (i.e. rating between -4 to - 1).

1 http://previous.espconference.org/previous_editions/81764/5/0/60

Respondents then ranked the themes' respective perceived importance by selecting the three most important themes within each of the four SWOT categories. We used a weighted sum procedure for this part of the analysis (i.e. scores per respondent: 3 = most important; 2 = second most important; 1= third most important) and presented the group result as the 'total importance score'. The maximum total importance score would have been 60, if all respondents chose the same theme as most important.

6.3 Results

6.3.1 Final survey respondent demographics

Following Surveys 1 (pilot) and 2, 20 YESS members participated in the final SWOT Survey 3 (~30% response rate). The average participant was 33 years old (min. 26 years, max. 45 years) with men and women equally represented. The sample covered researchers from 16 different countries. Participating YESS members were predominantly PhD students or postdoctoral researchers with an average of three years of ecosystem services research experience (min. one year and max. 9 years). The majority of participants stated that they had a background in environmental/conservation sciences (75%) or environmental/ecological economics (40%) (Table 6.1).

Table 6.1 Stated group affiliations of YESS survey participants (Survey 3)

Research/practice field	Frequency*
Environmental/conservation sciences	15
Environmental/ecological economics	8
Agriculture/forestry	5
Ecology/ecosystem sciences	5
Geography	4
Biological sciences	4
Environmental policy/governance studies	4
Sustainability studies	4
Others	5

* Multiple selections and open responses were possible. The number of participants was 20

6.3.2 Breakdown of outcomes by SWOT category

6.3.2.1 Strengths

Amongst the key themes identified across all four SWOT categories (Figure 6.4), the interdisciplinary approach was highlighted as the most important Strength of the ES framework (in this case a total importance score of 28 as a weighted sum). This was followed closely by the chance to improve accounting for nature (*score*=24) and taking a holistic approach (*score*=16). Raising societal awareness of ES benefits (*score*=9), the ability of the ES framework to reconnect people to nature (*score*=7) and the conceptual simplicity of the ES framework (*score*=5) were noted as key strengths, but were ranked lower in importance in comparison to the founding purpose of the ES concept (i.e. as a communication and advocacy tool; *score*=13). These findings indicate that survey respondents believe that fundamental Strengths of the ES framework lie in its interdisciplinary potential and in its ability to support improved decision-making. The respondent's agreement with the themes presented to them as Strengths ranged from 80%-100% (Table 6.2).

Table 6.2 Strengths of the ES framework identified.
'Importance score' and 'agreement with theme' measured during survey 3, as specified in section 6.2.

Survey theme	Total importance score	Agreement with theme (%)
Interdisciplinary approach: The diversity of disciplines involved in ES research strengthens the framework. The ES framework is methodologically flexible; it invites methods stemming from different disciplines to be applied and new methods to be developed.	28	95
Improved accounting for nature: Ecosystem services valuation might improve environmental decision making by accounting for the freely available and often intangible services provided by nature.	24	100
Holistic approach: The ES framework takes a holistic perspective that brings social, ecological and economic values together and highlights trade-offs between and within the three dimensions.	16	100
Advocacy and communication tool: The ES framework provides a tool to advocate and communicate nature conservation, by adding social and economic reasoning to ethical arguments.	13	100
Increased societal engagement: The simplicity and anthropocentric perspective of ecosystem services facilitates its uptake by a wide range of actors and sectors e.g. policy makers, media, businesses and the general public. This might lead to larger engagement of these groups in nature conservation processes.	9	85
Equity in natural resource allocation: The ES framework could lead to more equity in natural resource allocation through improved accounting for ES and more equitable distribution of natural resources amongst stakeholders.	9	80
Reconnecting people to nature: The link between the biophysical and human dimensions of ecosystems is made explicit by the ES concept. The ES framework makes nature conservation about what matters to people.	7	80
Conceptual simplicity: The ES framework outlines the multifaceted way in which society benefits from ES and addresses the cause-effect relationship between environmental impacts and human well-being in an easy understandable manner.	5	90

Survey theme	Total importance score	Agreement with theme (%)
Knowledge base: The ES framework enables us to categorize and organise our knowledge about the inter-connectedness of humans and nature. This is an important pre-requisite to improving our understanding of the complexity of these connections.	5	95
Works on different scales: The ES framework enables the use of different geographical and temporal scales to account for ES. It can account for ES that are provided to distant areas or future generations and allows cross- comparison of local and global impacts.	3	90

6.3.2.2 Weaknesses

Survey respondents agreed that the two main Weaknesses in the ES framework are an incomplete scientific basis (*score*=20) and inconsistencies in the application of a divergent range of available ES frameworks (*score*=16) (Table 6.3). Questionable measures of the intrinsic value of nature (*score*=14), the ambiguous language of the ES framework (*score*=13), and an overemphasis on monetary values (*score*=11), were also considered key weaknesses by survey respondents. The need for better tools (*score*=3) and the scale-dependence of outcomes (*score*=4) were the lowest ranked weaknesses of the ES framework. Overall, survey respondents highlighted the need for: greater methodological and terminological consistency; an overarching ES framework in the short term; further research; better understanding of ES supply; better understanding of the relationship of ES supply to maintaining or enhancing biodiversity in the long-term; and enhancing the influence of non-monetary methods to assess ES. The respondents' agreement across themes ranged from 65% to 80%, i.e. lower than for the strengths (Table 6.3).

Table 6.3 Weaknesses of the ES framework identified.
'Importance score' and 'agreement with theme' measured during survey 3, as specified in Section 6.2.

Survey theme	Total importance score	Agreement with theme (%)
Scientific basis incomplete: Our current understanding of the links between, biodiversity, ecosystem functioning and ecosystem services provision is poor.	20	70
Framework inconsistently applied: There are a range of ES frameworks in circulation, which do not entirely overlap. This might increase difficulties around data sharing and comparability of research results.	16	80
	14	70

Survey theme	Total importance score	Agreement with theme (%)
Disregarding intrinsic value of nature: The anthropocentric view of the ES framework and its application in decision making might cause an imbalance between biodiversity conservation targets and social and eco- nomic objectives, with dominance of the latter two.		
Ambiguous language: The terminology used in the ES framework is open to interpretation.	13	70
Overemphasis on monetary values: An overemphasis of the monetary values of ecosystem services within ecosystem assessments might be contrary to the original objective of making ecosystems count.	11	80
Some ecosystem services poorly represented: The cultural, regulating and supporting services tend to be less well represented in ES research and assessments than provisioning services.	9	65
Large resources needed to apply framework: Implementing the ES framework in practice requires consider- able resources (e.g. data, finance, expertise).	8	75
Inaccessible to non-specialists: Those who do not work in the ecosystem services field, or are not scientists, might find the ES framework terminology and methodology hard to understand.	6	65
Benefits poorly understood: It is non-trivial to aggregate, analyse and present the benefits received from ES. Many people might not necessarily acknowledge benefits of the ES identified by researchers.	6	75
Oversimplification: The ES framework is sometimes used in a way that oversimplifies ES to the extent that they are poorly represented and assessed. This might lead to misguided environmental decision making.	5	70
Difficult to apply: The ES framework is difficult to implement in practice. It is currently considered to be methodologically challenging to combine the large number of ES in one assessment.	5	75
Scale-dependence of outcomes: The ES framework is applied in different ways across different scales (local, regional, national etc.), with a range of possible outcomes at each scale.	4	70
Need for better tools: The ES assessment tools currently available to practitioners and researchers are in adequate and need to be improved.	3	75

6.3.2.3 Opportunities

A list of 11 themes within the Opportunities category reflects the positive outlook of survey respondents for future potential development in the ES framework. Alignment with policies and strategies (*score*=24) and existing tools and methods (*score*=18) were ranked as the top two opportunity themes. These were followed closely by increasing environmental awareness (*score*=17), and opportunity for better realising sustainability (*n*=16) (Table 6.4). Other themes within this quadrant have the potential to complement the top opportunities: for example, more funding (*score*=7) could align with policies and strategies, technological advancements (*score*=4) can advance existing tools and methods, and demand for ecosystem management (*score*=14) can align with increasing environmental awareness.

Table 6.4 Opportunities identified for the ES framework.
Importance score' and 'agreement with theme' measured during survey 3, as specified in Section 6.2.

Survey theme	Total importance score	Agreement with theme (%)
Alignment with policies and strategies: Existing environmental policies and strategies already in place or currently under development are well suited to fit the ecosystem services concept, such as the CBD Strategic Plan for Biodiversity and the EU Biodiversity Strategy among others.	24	75
Alignment with existing tools and methods: ES framework can be easily integrated into existing tools and methods of environmental policy, such as environmental impact assessment and cost-benefit analysis.	18	95
Increasing environmental awareness: The ES framework fits into the growing global awareness of environ- mental issues, including climate change and its potential long-term impacts.	17	85
Operationalization of sustainability: There is a need to operationalise the term of 'sustainability' and reduce its vagueness. The ES framework with ecosystem services indicators and assessments could provide the framework to make sustainability more assessable and traceable.	16	95
Demand for ecosystem management: The demand to improve ecosystem-based management, as well as the necessity to increase its acceptance might support the use of the ES framework.	14	85
Interest of societal actors: ES framework has received recognition and support from a wide range of actors within society, including public media, researchers, the business sector and stakeholders involved or affected by environmental management.	9	80
Policy awareness: Governments are aware of the ES framework as a result of the Millennium Ecosystem As sessment and The Economics of Ecosystems and Biodiversity initiative. Current demand for national assess ments of natural resources is high.	8	75

Survey theme	Total importance score	Agreement with theme (%)
More funding: Funding bodies are interested to support research with societal impact and interdisciplinary projects. There is also the opportunity to get more funding by highlighting the benefits that nature provides to humans.	7	85
Technological advancements: Fast increasing computing power allows us to use more complex system models to analyse data. Technological advancements also allow new ways of interacting with audiences through online media, video, games, and presentations.	4	85
Institutionalisation of nature's value: Establishment of legal requirements to protect the environment and the ES it provides. Incorporating the regulation of ES into laws and constitutions. Example set by Ecuador.	2	85
People's utility: People tend to value their self-regarding benefits higher than other-regarding values (including non-humans). The ES framework might benefit from this kind of thinking.	1	60

6.3.2.4 Threats

Resistance to change in environmental practices (*score*=32), difficulty of interdisciplinary work (*score*=19) and insufficient funding (*score*=14) were the top three Threats as selected by survey respondents. Interdisciplinarity of the ES framework (*score*=19) was highlighted as a potential Threat due to different technical terminology and applications. The lack of institutional capability (*score*=13) and loss of political interest (*score*=13) were equally perceived as Threats for the ES framework. An overall assessment of SWOT themes across all categories revealed that at least half of survey respondents were in agreement for most SWOT themes (Figure 6.6). Only the Threat theme 'diversion from sustainability goals' received less than 50% agreement from survey respondents. There was greater agreement across survey respondents within the Strengths quadrant (92%) as compared to Opportunities (82%), Weaknesses (72%) and Threats (69%) quadrants (Table 6.5). Broad agreement with themes was expected since they were derived from survey respondents' contributions in Survey 2.

Table 6.5 Threats identified for the ES framework.
'Importance score' and 'agreement with theme' measured during survey 3, as specified in the Section 6.2.

Survey themes	Total importance score	Agreement with theme (%)
Resistance to change environmental practices: Even if understanding of human impacts and nature conservation benefits is considerably improved, changing environmental practices might not follow automatically.	32	85
Difficulty of interdisciplinary work: ES framework requires inter-disciplinary collaborations, which are hard to truly achieve in practice.	19	75
Insufficient funding: Funding for research might suffer severe cuts.	14	75
Loss of political interest: In the mid- to long-term future, policymakers might lose interest in promoting or implementing ES framework, if expectations for practical solutions of environmental management cannot be met by the ES framework.	13	80
Lack of institutional capability: Insufficient institutional capacity and expertise to implement treaties, agreements, conventions etc.	13	55
Competing approaches: Different approaches to biodiversity conservation and sustainable resource management divert interest away from ES research and assessments.	8	55
Loss of interest from researchers: Due to pressure of working at the cutting-edge of science and publishing novel approaches, scientists might lose interest in researching ES framework and move on to new approaches.	7	60
Misuse of environmental tools: Environmental tools can be incompletely or incorrectly applied, and therefore become ineffective or worsen the situation.	6	70
Lack of awareness across general public: Overall low understanding of ecosystems among general public including stakeholders and policy makers. These groups might be disengaged, if their interests are not sufficiently taken into account by the ES framework, or if low ecological understanding prevents buy-in to the ES framework.	5	85
Environmental ethics viewpoint: Approaches such as the ES framework, which put human values before nature's intrinsic value, might face opposition by some factions within the nature conservation field and the general public.	2	80
Diversion from sustainability goals: Society at large may lose interest in nature conservation and sustainability goals, thus removing the demand for the ES framework.	0	35

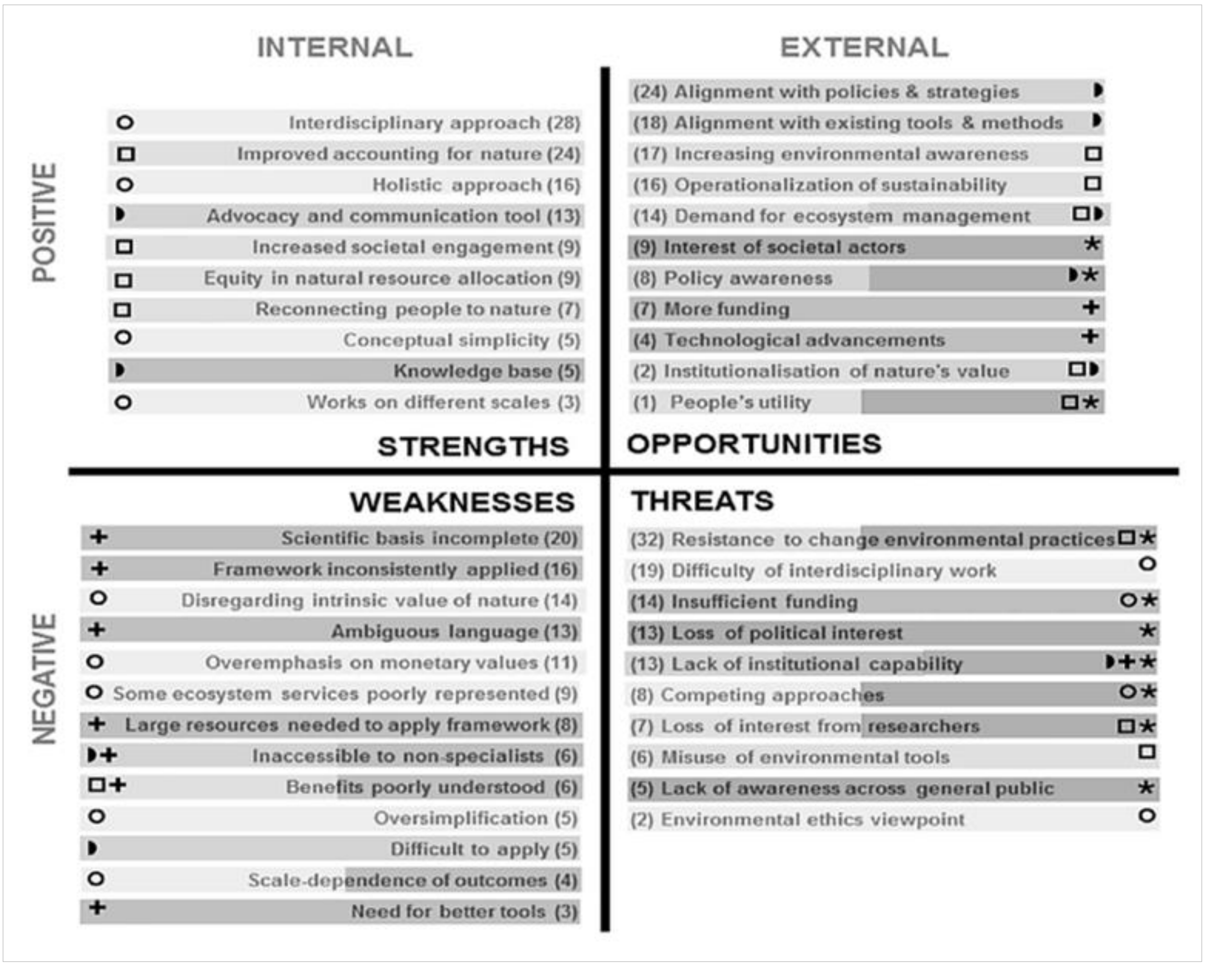
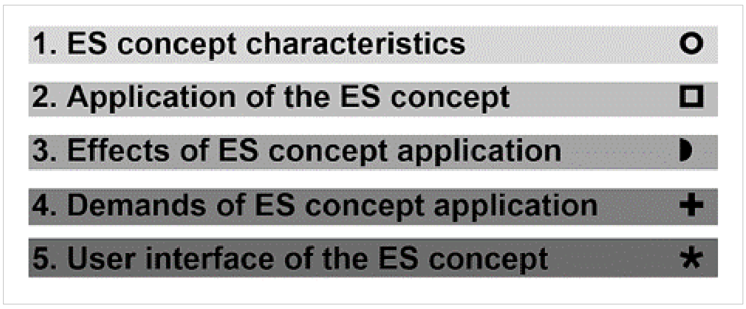


Figure 6.4 **SWOT themes ranked according to their total importance score.**

The score is expressed as weighted sums (scores per respondent: 3 = most important; 2 = second most important; 1 = third most important; 60 = maximum group score). Symbols ○ □ ◗✚★) and shading indicate the 5 different strategy topics that emerged from the SWOT themes. For details see section 3.3

6.3.3 Strategy development based upon the SWOT

Following on from the SWOT, the authors grouped themes into 5 different strategic areas (Figure 6.4):



Certain SWOT themes belong under more than one strategy. When counting the items per topic, it became clear that these are distributed irregularly in the different quadrants of the

SWOT diagram (Figure 6.5). While, for instance, Strategy 1 themes are concentrated within quadrants S, W and T, Strategy 5 themes have been identified only in quadrants O and T– perhaps unsurprisingly, given that the 'user interface' strategy might only be expected to be represented in the 'external' quadrants.

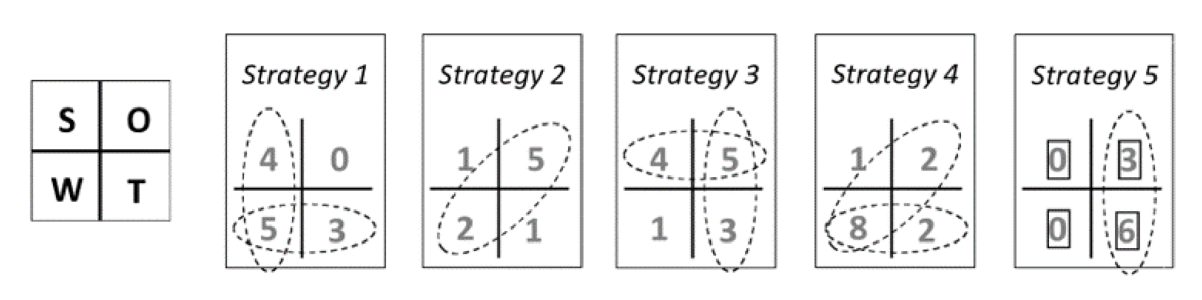


Figure 6.5 Conceptual representation of strategy development and distribution of SWOT themes for each strategy topic.

Far left: reminder of the four quadrants constituting the SWOT assessment. Dashed lines highlight the quadrants considered for each strategy 1–5. The number of SWOT themes identified within each quadrant is given for each strategy.

This distribution of themes across the SWOT quadrants was used as a starting point for identifying topic related strategies. These were considered useful under the assumption that a single overarching strategy may not be suited to capture the complexity of the problem and may also not be sufficiently tailored for those working in their respective context within the ES framework. Further, depending upon their expertise, survey respondents may have been interested in certain topics only – thus, topic-specific strategies would likely be more easily adopted.

6.3.3.1 Strategy 1 – ES framework characteristics

In Strategy 1 we consider a **strength–weakness (SW)** combination, and how to use identified Strengths to overcome Weaknesses. By contrasting the four highest scoring strengths with the five highest scoring weaknesses (Figure 6.5), this strategy would focus upon the characteristics that form the ES framework via:

- extending the interdisciplinarity of ES research, with an emphasis on further strengthening links with the social sciences and increasing involvement from the arts and humanities;
- creating holistic frameworks that contain clear and concise language so the approach can be consistently applied as communication and advocacy tools; and,
- increasing the representation and analysis of ES beyond utilitarian values to highlight broader shared and social values, and the intrinsic value of nature, including by

highlighting synergies between intrinsic value and supporting and regulating services, and shared values and cultural services.

It is important to highlight that both the difficulty of interdisciplinary work and the variety of competing approaches within the Threat quadrant (Figure 6.5) may not be reduced under the proposed **SW** strategy. Thus, a **strength-threat** strategy could be applied to reduce these threats. Pursuit of such a strategy should improve the ability of ES analyses to make progress on improving the sustainability of human-environment interactions.

6.3.3.2 Strategy 2 – Application of the ES framework

The second Strategy would concern the use of external Opportunities to overcome internal Weaknesses, with themes residing in the weakness–opportunities (WO) quadrants. Two of the highest scoring Opportunities acknowledge the potential alignment of the ES framework with existing agreements (e.g. the CBD Aichi targets, the UN Sustainable Development goals), and with existing tools (e.g. spatial conservation planning, environmental impact assessment, remote sensing). However, the Weaknesses suggest that this approach is inaccessible to non-specialists and difficult to apply. A **WO** strategy could focus on using the identified opportunities in two ways:

- Enhanced communication to elucidate how ES can be linked and add value to key performance indicators, and other measures that determine policy implementation success (e.g. measures of sustainable economic development). This broader picture could facilitate a better understanding of ES; and,
- ES specialists assisting and working with non-technical audiences in identifying and applying the most relevant and effective ES methods and tools for the required application. The result could be greater uptake and ownership of the ES framework.

6.3.3.3 Strategy 3 – Effects of an ES framework application

Thirdly, we consider the potential use of the ES framework to overcome Threats, given a combination of **strengths, opportunities and threats (SOT)**. Blending the existing Strengths of the ES framework (which includes improved accounting for nature, increased societal engagement, equity in natural resource allocation and reconnecting people with nature) with Opportunities (specifically an increase in environmental awareness and operationalization and institutionalisation of the ES framework) could offer scope for increasing environmental awareness and understanding (countering the identified threat of low awareness).Equally, drawing upon these Strengths could ensure that implementation of the ES framework becomes or remains a political imperative (at the same time seeking to address any threat of a loss of political or researcher interest), and that the institutional application of the ES framework adds value. A strategy containing these elements could also consider seeking to showcase the ES framework itself as a way of measuring the effects of resistance to change environmental practices (a third Threat theme).

6.3.3.4 Strategy 4 – Demands of an ES framework application

The fourth Strategy concerns dealing directly with barriers to the application of the ES, with a focus upon weaknesses, threats and some opportunities (WTO). Overcoming Weaknesses and Threats is considered likely to be challenging. The strategic direction is heavily influenced by 8 Weaknesses, ranging from an incomplete scientific basis, to the fact that large resources are needed to apply frameworks, to the need for better tools. Insufficient funding is highlighted as a Threat, However, funding is also an identified Opportunity – so understanding exactly where the funding gap lies, and what causes it, would be a key challenge to deal with under this strategy. Many of the identified Weaknesses – disregard for intrinsic value, oversimplification, ambiguous language, inaccessibility – are perhaps at the root problems of conceptual convergence and communication. These Weaknesses are compounded by Threats such as loss of interest and lack of awareness. A strategy for resolving these challenges must involve collaboration between those researching and implementing the ES framework, as well as a focus on communication to non-specialists. Although the Opportunity for technological advances through applying the ES framework was highlighted, it is endangered by the Threat of a lack of institutional capacity. The approach requires extensive support in terms of human and financial resources, to develop capacity, if it is to realise the opportunities it presents.

6.3.3.5 Strategy 5 – Wider interface with the ES framework

Finally, a strategy that focuses upon external issues, i.e. **opportunity-threat (OT)** quadrants, is necessary. This would concern the public face of the ES framework – specifically, how users (such as policy makers, researchers and the general public) engage with the approach. Identified Opportunities highlight interest in and awareness of the ES framework on the part of a range of stakeholders. These are in contrast with a number of identified Threats such as: resistance to change in environmental practices, loss of political interest, lack of awareness across the general public and loss of interest by researchers. Building upon the topic of communication mentioned in Strategy 4, careful communication and dissemination measures would need to be designed that build upon existing interest and awareness – and, if the approach does prove successful in practice, ensuring that success is evaluated and publicised so as to avoid losing interest on the part of both researchers and policymakers. In turn, this latter requirement suggests the need for monitoring and detailed ex-post evaluation of the implementation of the ES framework. A key Opportunity, as mentioned in Strategy 2, is alignment with existing policies. By seeking to support existing agreements and policies, and providing useful mechanisms for policy implementation rather than replacing them, it could perhaps be ensured that the ES framework circumvents the threat of resistance to change. The same reasoning could apply to the Threat of competing environmental approaches.

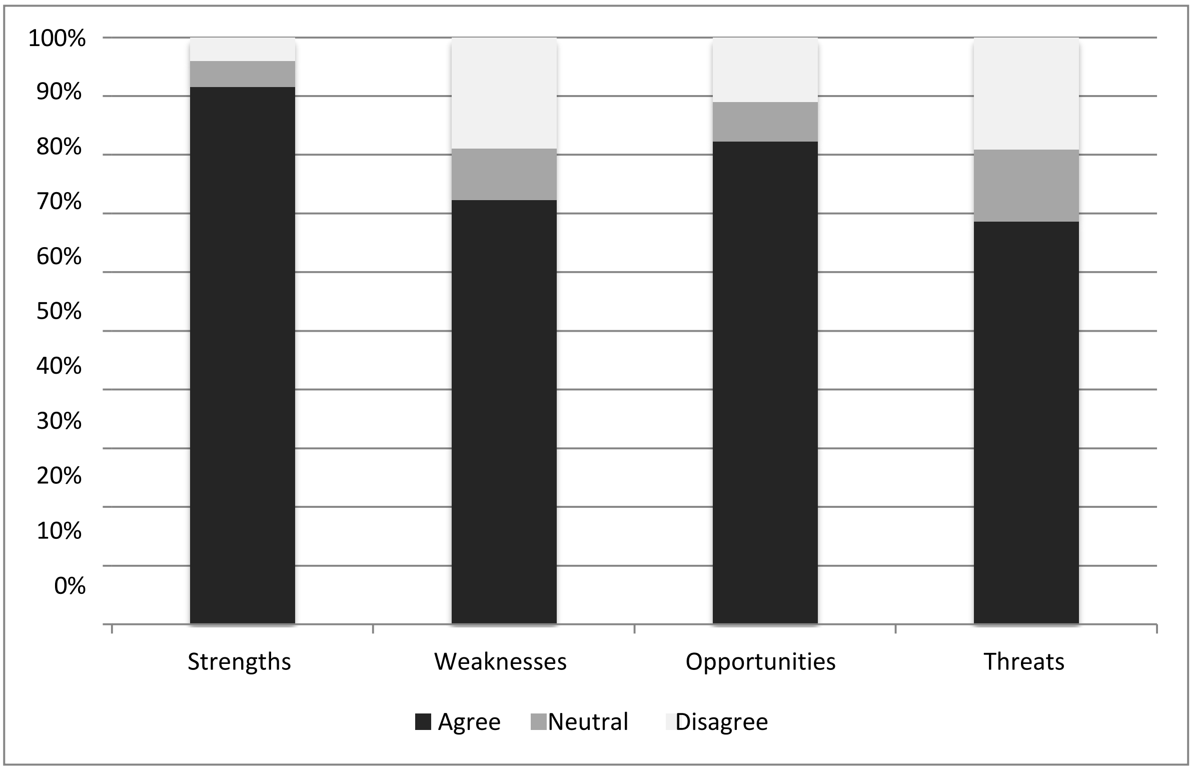


Figure 6.6 Overall agreement with the themes developed for each SWOT category.
Agree = rating between +1 and +4; neutral = rating 0; disagree = rating between -1 and -4.

6.4 Discussion

The YESS group carried out a three-stage survey constituting a SWOT analysis of the ES framework. The aim of the assessment was to seek agreement on the perceived utility of an ES-based approach from a set of early career researchers and practitioners, and to offer the beginnings of some potential strategies for taking the framework forward based upon findings. In this way, we have extended the existing literature on the ES framework, which, whilst highlighting challenges to the use of ES concepts, is usually not structured around a SWOT analysis, and contains limited discussion around such strategies. While strategies to address challenges related with the application of the ES concept have been discussed elsewhere (see de Groot et al., 2010; Baker et al., 2013; Schröter et al., 2014), the strategies we identify emerge from a systematic approach to address perceived weaknesses and threats of ES-based approaches. The identified strategies should not be seen as exclusive, rather, they arise from focusing upon different combinations of the SWOT quadrants, and therefore can be complementary. Numerous YESS members including 20 participants in the final survey (Survey 3), plus attendees at an ESP conference in Bali, gave input at the various stages of the SWOT analysis. There was very strong agreement by participants in relation to the most highly ranked Strengths, Weaknesses, Opportunities and Threats. The outcomes suggest that key Strengths include that the ES framework is interdisciplinary, provides a means for improved accounting for nature, is holistic, and is a useful advocacy and communication tool. Current Weaknesses include that the scientific basis for the approach is incomplete, ES frameworks are inconsistently applied and do not necessarily account for nature's ‘intrinsic’ value, and that the language of ES can be ambiguous. External Opportunities for the ES framework include alignment with different existing and emerging policies and strategies, the implementation of the approach through existing tools and methods, and the possibility that environmental awareness is increasing more generally. Finally, identified external Threats include general inertia regarding change in environmental practices, the broader difficulties with successful interdisciplinary collaboration, and insufficient funding to fully realise the potential of the ES framework. Subsequent consideration of the themes coming out of the SWOT suggested five key strategic areas for furthering the ES framework: (1) approach characteristics; (2) application of the framework; (3) effects of application; (4) demands of application; and, (5) interface with the framework. Whilst the development of full strategies for improving and (if appropriate) embedding the ES framework into practice is beyond the scope of this article, we make some suggestions based on SWOT outcomes, and our findings here could influence the development of strategies.

6.4.1 Strategies

Strategy 1 is based around how existing Strengths with the approach might be used to overcome Weaknesses. Options include using the interdisciplinary nature of the ES framework, and the associated broad network of researchers working in the space, to further develop the currently incomplete scientific basis (see Bennett et al., 2015). Equally, since the approach has the Strength that it requires practitioners and policymakers to take a holistic view, it should readily be able to incorporate additional considerations that it currently lacks (e.g. inclusion of broader shared and social values; Kenter et al., 2015). Given the approach's potential Strength as an advocacy tool (Costanza et al., 2014), a focus upon this strength could result in the approach being used to leverage input from many more stakeholders than it currently does, to help ensure more equitable use of ES. However, there are also challenges: not least that interdisciplinary science is not easy, or that some stakeholders may remain unwilling to engage with the ES framework if they consider it to violate notions of intrinsic value of nature (Lang et al., 2012). The notion that the ES framework should go beyond utilitarianism to include broader values is now broadly recognised (Kenter et al., 2015), as reflected in explicit in the inclusion of shared or social values in major assessments (e.g. TEEB et al., 2012; UK National Ecosystem Assessment, 2011, 2014). The degree to which the ES framework is or may be able to incorporate non-anthropocentric values is more contentious. There has been debate around whether the concept of services to human-wellbeing is by definition anthropocentric, and not amenable to notions of intrinsic values (Gómez-Baggethun and Ruiz-Pérez, 2011; Braat and de Groot, 2012; Jax et al., 2013; Costanza et al., 2014; Schröter et al., 2014), and our survey suggests that most participants recognise the disregard of nature's intrinsic value as a weakness of the ES framework (Table 6.3). Nonetheless, notions such as habitat services (TEEB et al., 2012), and conceptualisations of cultural ecosystem services (e.g. Chan et al., 2012; Daniel et al., 2012) can provide a hook for bringing in biocentric values that go beyond the economic notion of existence value. Others have suggested a new ethical approach altogether that aims to transcend the intrinsic-instrumental, biocentrism–anthropocentrism divide (O'Neill et al., 2008). Although delving into this debate is beyond the scope of this article, it is useful to point out that survey participants also associated this issue with application of the ES framework in decision making, and thus broader institutional concerns around how the ES framework is applied. This runs parallel with two aspects of ES that, according to Gómez-Baggethun and Ruiz-Pérez (2011), are often neglected: (i) the role of the particular institutional setup in which environmental policy and governance is currently embedded; and (ii) the broader economic and socio-political processes that have governed the expansion of pricing into previ usly non-marketed areas of the environment.

Strategy 2 addresses the use of external Opportunities to overcome internal Weaknesses. Two key Opportunities involved the potential alignment of the ES framework with policies and strategies, and with existing tools and methods (e.g. spatial conservation planning, remote sensing, environmental and economic impact assessment). Meanwhile, one potential Weakness was that the approach can be inaccessible to non-specialists, and difficult to apply. Finding ways to align the ES framework more closely with existing policies, strategies and methods could facilitate a better understanding of ES for those not working directly in the field. This is a strategy that can be considered already in progress (e.g. incorporating ES into landscape planning; Albert et al., 2014), but it is nevertheless worth emphasising that doing so is likely to be productive, developing guidelines and providing examples of applied research on how this can be done, highlighting the ongoing need to communicate the basic ideas behind the ES framework (according to the Strengths identified, those ideas are essentially rather straightforward; Figure 6.4), and developing knowledge exchange networks that bring together policy makers, research and practitioners (e.g. the UK Ecosystems Knowledge Network[2]). Focused efforts for ES specialists to work with non-technical audiences in identifying and applying the most relevant and effective ES methods and tools, for a given application, should result in greater uptake and ownership of the ES framework. Here transdisciplinary approaches, involving the co-production of knowledge offer much promise (Liu et al., 2010; Jahn et al., 2012; Reyersa et al., 2015) Encouraging the use of existing familiar tools and methodologies to implement the ES framework could equally support uptake, and help address the ongoing challenges around how best to operationalise the approach.

Strategy 3 targets the effects of applying the ES framework given a combination of the relevant Strengths, Opportunities and Threats. Blending the existing Strengths of the ES framework (e.g. conceptual simplicity, increased societal engagement, reconnecting people to nature) with Opportunities could well support an expanding general awareness of and willingness to engage with environmental issues (e.g. within industry; Bull et al., 2015), increasingly politicising the value of implementing the ES framework. Yet it must be considered that a 'loss of political interest' was identified as one of the major Threats to the ES framework. So long as the ES research community builds firmly upon the Strengths and Opportunities identified here, and given recent developments in ES policy – such as the

[2] http://ecosystemsknowledge.net

potential incorporation of mandatory ES assessment into European environmental impact assessment requirements, and the recent establishment of IPBES – it would seem unlikely that political interest for the framework will fade in the short term. However, it cannot be taken for granted that this will perpetuate in the longer term, and so any strategic approach must contain measures to keep ES on the political agenda, and importantly ensure that ecosystem management activities are implemented on the ground in order to bridge research-policy implementation gaps. Another Threat to the ES framework is resistance to changing environmental practices – one can understand the potential for fatigue on the part of policymakers and the public, given how substantially concepts within conservation (and consequently policy development) have changed over recent decades (e.g. Mace, 2014). Arguments based on key Strengths with the ES framework, such as being characterized by conceptual simplicity and working on multiple scales, as well as explicit recognition and management of Weaknesses (e.g. perceived focus on monetary values) will continue to be required in order to overcome this overarching Threat. The fact that the ES framework provides a potentially strong advocacy and communication tool may be a useful asset in arguing for its wider implementation, especially with regards to engaging with the business sector (Reyersa et al., 2015). Here working with bridging agents can be powerful (Braat and de Groot, 2012; Ruckelshaus et al., 2013). However, ultimately the ES framework is only a means to diffuse ends, and it is conceivable that at some point the ES framework is superseded by other conceptualisations of sustainability and human-nature relations that prove more useful, persuasive or effective in terms of being embedded into practice.

Strategy 4 brings a focus upon Weaknesses, Threats and Opportunities. Research needs for the ES framework have been identified in the literature (e.g. Braat and de Groot, 2012; Bennett et al., 2015). Clearly, input of additional funding and resources to develop the ES framework would begin to address some of these challenges – and indeed insufficient funding has been highlighted as a Threat. But this does not constitute a strategy in itself, as the ES framework competes with many other fields for research funding. The strategy would be to use the identified Strengths and Opportunities to make the case for increased funding to develop and implement the ES framework: such as, e.g. on-going alignment with existing governmental or international policies and strategies. Equally, reducing the costs and efforts required for applying the ES framework will be important. Opportunities for reducing costs and efforts can include uptake of recent technological developments, utilising synergies between research projects and strengthening the networking and exchange of involved scientists rather than 're-inventing the wheel', and striking a balance between application of existing knowledge and methods based on agreed frameworks and protocols and ongoing debate and innovation. The Opportunity provided by technological advancements in terms of applying the ES framework (e.g. ES models and algorithms, hardware for monitoring components of ES), must be considered in the context of a lack of institutional capacity (as a Threat) in some cases. This might perhaps be mitigated through the open exchange of tools and knowledge, as well as key datasets.Further Opportunities could include the development and testing of less data-heavy tools and methods, for instance, by using proxies and existing datasets (e.g. Helfenstein and Kienast, 2014 Jacobs et al., 2015).

Themes informing Strategy 5 are within the Opportunities and Threats quadrants. This strategy relates to the 'public face' of the ES framework – specifically, how to encourage users (such as policy makers, societal actors, researchers and the general public) to engage with the approach. The Opportunities highlight interest and awareness of the ES framework on the part of a range of stakeholders. This can be used to promote the approach, but must be balanced with recognition of the difficulty in maintaining a consistent conceptual framing (Lamarque et al., 2011). Equally, public acceptance of the ES framework must overcome any future potential loss of political interest, resistance to change in environmental processes, lack of awareness across the general public and loss of interest by researchers. The ES framework and concepts behind it require clear communication across a range of audiences if the approach is to be successfully implemented, and the concept and the concept of ecosystem services should be mainstreamed across sectors, outlining the potential benefits of doing so (Cowling et al., 2008; Sitas et al., 2014). Note, finally, that a potential Threat that was raised in the pilot survey was the chance of societal diversion from sustainability goals more generally. This was not retained as a Threat to the ES framework by the last survey, perhaps as the respondents trust society will continue to pursue sustainability goals in some capacity (despite changing contextual conditions, e.g. austerity measures and economic crisis).

6.4.2 Study limitations and further work

The survey sample size (20 researchers in Survey 3) was small in absolute terms and thus cannot be assumed to represent the view of early career ES researchers generally. Nonetheless, there was a good degree of variety in the age, sex, nationality and experience with ES of those participating, which may have minimised potential biases in responses. As further research, it would be interesting to extend the survey more widely to other respondents and examine the extent to which the findings are in agreement with the broader ES community, especially of the opinions and perceptions of more long-established researchers in the field of ES. The respondents to the survey were biased towards the natural sciences and environmental and ecological economics. Therefore, the outcomes may be different if the same survey approach was carried out using a more diverse academic sample (e.g. including more respondents with humanities and broader social science backgrounds), or decision makers. Similar future exercises could be undertaken to draw insights among and between different groups of ES users, stakeholders, researchers or practitioners. The strategies we have outlined should be seen as suggestive, rather than concrete guidelines for action. We offer them as a means for combining the findings of our surveys in a way that is practical and useful to future directions in the theory and practice of the ES framework. Beyond potential biases associated with participants in the study, there are important linguistic uncertainties to consider. For a start, we consider a valuable component of the survey to be the variety in nationalities represented by respondents, but this same factor means that there is likely to be uncertainty introduced to the identification of themes resulting from subtleties in translation between different native languages. Such uncertainty extends to vaguely defined technical terms, and indeed, the definition of 'ecosystem services' itself. Here, we have used the TEEB definition, but others exist e.g. "the benefits people obtain from ecosystems" (Millennium Ecosystem Assessment, 2005); "the benefits provided by ecosystems that contribute to making human life both possible and worth living" (UK National Ecosystem Assessment, 2011), which are clearly rather different. ES can also be defined in more ecological terms, and in too many other ways to list here (Fisher et al., 2009). It is possible that the survey results would have been rather different with a different starting definition of ES – and therefore it should be considered that the very choice of definition encapsulates a certain perspective into the findings here. Although SWOT analysis stands out for its simplicity and value in focusing attention on key issues, it entails limitations – for example unclear classification of items as strengths, weaknesses, opportunities or threats, or over-subjectivity in the generation of themes due to compiler bias (Pickton and Wright, 1998). Nevertheless, the results of the SWOT analysis we conducted here allow assessing the relative importance of different themes under the four SWOT categories, from the perspective of a group of ES early career researchers and practitioners. The key utility in the research presented here is thus to review and capture, in a structured way, a variety of considerations relevant to the strategic development of the ES framework that are otherwise not collated within the literature. Another important aspect of conducting such a SWOT analysis is the process itself (Pickton and Wright, 1998). In this research, it provided a platform to exchange ideas and find agreement or otherwise among the YESS community, and contributed to building the community itself.

6.5 Conclusions

Critical analysis of the ES framework can already be found in literature, however, the innovative character of this research was that such analysis was systematically structured using a SWOT characterisation, allowing us to derive strategies for further development of the ES field. Another important feature of this research is that it reflects the views and perceptions of early career researchers and practitioners, who will help shape the ES field in the future. Our work emphasizes that the ES framework can be viewed not only as a way of improving decision-making, but also as a means for more widely interpreting and communicating the complexities of the interaction between humanity and nature. Further, it is suggested that the ES framework is only likely to truly find traction in implementation when more deeply merged with existing policies and incorporating existing tools. Interestingly, the ES framework appears in some senses contradictory – being valued by specialists as a simple means of communicating the importance of nature conservation, whilst also being potentially an oversimplification and characterised by ambiguous language, and this tension suggests its relevance as a bridge between research and practice. Provided sufficient funding and political will is maintained, e.g. through initiatives such as IPBES, the ES framework may yet provide a powerful means for facilitating interdisciplinary research, and for better incorporating sustainability into policy and practice.

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Appendix A. Supplementary Information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.ecoser.2015.11.012.

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Chapter 7
Synopsis

This chapter outlines key results and summarises the theoretical, methodological, scientific findings and policy contributions of the thesis to the literature on forest ecosystem services multifunctionality. The chapter further presents on the limitations of the thesis, future research directions and conclusions.

The thesis explores the economics of production of forest ecosystem services multifunctionality by analysing ecosystem services concept in respect to multifunctionality, cost of joint production, forest institutional property rights and community forestry. The details of the findings are discussed thoroughly in the respective chapters in the thesis. Chapter 1 reviews ecosystem services concept theoretical debates and introduces multifunctionality in respect to production of services and livelihoods. Chapter 2 presents a theoretical translog cost function and an empirical model for estimating forest ecosystem services multifunctionality. Chapter 3 discusses forest institutional property rights linkages to multifunctionality based on livelihoods and forest ecosystem conditions. Chapter 4 studies the role of community forestry in joint supply of forest ecosystem services and livelihood outcomes. Chapter 5 discusses multiple conceptualizations of nature in ecosystem services debates and Chapter 6 presents a Strengths Weaknesses Opportunities and Threats (SWOT) analysis the ecosystem services framework.

7.1 Summary

Are Ecosystem Services Complementary or Competitive? An Econometric Analysis of Cost Functions of Private Forests in Vietnam (Chapter 2)

Conserving forest ecosystems have become increasingly important in recent years given their unprecedented rates of decline in human history and the increasing rate of forest species extinction. Ecosystem services provided by forests have multifaceted relevance to society, including their global contribution to climate change protection and improving livelihoods of communities. Production of forest ecosystem services multifunctionality enhances the relationship between nature and society. Methodological developments in assessing cost of joint supply of services and designing of input based payment mechanisms and instruments that consider livelihoods of forest communities is necessary in forest ecosystem services management. One major challenge in ecosystem management is understanding the jointness in production (multifunctionality), i.e., the interdependences in the simultaneous provision of different services from the same forest land when designing ecosystem management strategies and policies. Cost information and structure offers the basis for setting efficient targets for provision of externalities and for cost-effective management strategies to meet such targets (Lambini et al., 2018).

Modelling the production structure of forest ecosystem services multifunctionality by applying a dual cost function approach is appropriate in dealing with the multiple joint output production in forests and assessing cost complementarities and trade-offs between the provisioning of different ecosystem services. Production cost of provisioning of forest ecosystem services is quantified by estimating the marginal cost of provisioning and assessing potential complementarity or competitiveness relationships between timber, Non Timber Forest Products (NTFPs), the quantity of deadwood in the forests (taken as an indicator of biodiversity) and forest carbon storage capacity.

The analysis of model results show marginal cost of timber harvesting decreases when the amount of carbon sequestration increases (complementarity between timber and carbon), suggesting that timber production and carbon sequestration policies can be implemented as part of a (diversified) multifunctional forest. Furthermore, the marginal cost of Non Timber Forest Products (NTFPs) decreases with respect to the amount of deadwood, also implying cost complementarity. However, there is competitiveness between timber production and the presence of deadwood. The analysis found no significant effect between carbon sequestration and NTFP and biodiversity conservation-using deadwoods as indicator. This implies forest owners can increase provisioning of forest carbon as a sink without incurring any additional costs based on current forest management in their forest.

A comparative analysis of the effects of institutional property rights on forest livelihoods and forest conditions: Evidence from Ghana and Vietnam (Chapter 3)

Management and provisioning of forest ecosystems is characterised by several institutions. Forest institutional property rights (formal and informal rules) assessments are significant in the provisioning of forest ecosystem services and guaranteeing livelihoods of communities (Lambini and Nguyen, 2014). Hence reviewing their effectiveness in the context of multifunctionality is therefore relevant. To understand the linkages between institutional property rights, livelihoods and forest ecosystem conditions, these three (3) conceptual debates are reviewed and applied to the analysis: (1) New Institutional Economics (NIE), (2) Property Rights Theories and (3) Sustainable Livelihoods Framework. A conceptual Venn diagram is illustrated to demonstrate a possible logical relationship between these three theoretical concepts. At the core of this illustration is a “perfect” interaction of all three (3) demonstrating effective interactions of a sustainable institution that promotes an efficient and effective “functional institution-clearly defined property right-sustainable livelihood outcome” scenario. The findings show that forest institutional property rights in Vietnam are much more clearly defined and secured than in Ghana hence Vietnam's higher status of forest livelihoods and forest ecosystem conditions. These findings support our initial hypothesis that secured exclusive property rights (communal, state and private) enhance sustainable forest livelihoods and forest ecosystem services. These conclusions are however determined by local contextual conditions, the existing tenure arrangements and formal and informal rules guiding forest management in the respective case study countries.

Impact of Community Based Conservation Associations on Forest Ecosystem Services and Household Income: Evidence from Nzoia Basin in Kenya (Chapter 4)

Community forestry plays an important role in enhancing efficient, effective, transparent and sustainable forest resource use in most tropical forest regions and often perceived as a win-win solution in conservation and development discourse, given that a decentralised resource management process empowers communities. Community based conservation groups and bottom-up approaches are considered best alternatives to tackling household poverty and opportunity cost of forest conservation in most developing countries (Lambini and Nguyen,2021). Review of the literature suggests mixed results making the topic on community forestry still a subject of heated debate within forest economics literature. Furthermore, empirical evidence on outcomes are limited at best, and leans towards livelihood outcomes in most impact studies. Few impact assessments have rather focused on forest cover (% of forest area, rate of deforestation or afforestation and the annual change rate) and forest conditions (basal area, tree density and species richness) and scarcely study the provisioning of multiple forest ecosystem services and livelihoods in community forestry literature. Using a propensity score matching technique, the paper measures the impact of belonging to a Community Based Conservation Association (Community Forest Associations (CFAs) and Wildlife Conservation Associations (WCAs)) and how that influences conservation group members supply of ecosystem services and livelihoods conditions by comparing them to non-members. The conclusions from the impact assessment models after robustness checks and tests show that Community Based Conservation Association households increase forest ecosystem services (forest carbon, soil erosion control and biodiversity conservation) with significant decreased total household forest revenues. Household payment subsidies as incentives to community based conservation groups are critical in increasing forest ecosystem services supply and compensating for the loss of incomes in communities.

Multiple conceptualizations of nature are key to inclusivity and legitimacy in global environmental governance (Chapter 5)

The concept of "ecosystem services" since its introduction in ecosystem science highlighting the societal values on nature's functions is faced with multiple concepts and worldviews. Different cultures and people live in, from and with nature in diverse ways. Understanding the meaning of nature can be different to different individuals and societies and mostly shaped by historical and cultural context. This diversity of conceptualizations of nature across the globe constitutes an important resource for envisioning multiple ways to govern human-nature relations. However, multiple conceptualisation of diverse values of nature can leads to governance challenges, especially in ecosystem services mainstreaming to indigenous and local communities. These different framings suggest that there is just one single concept of nature and underscore the different cultural understandings of nature across the world, for example by investigating how this is reflected by language, as one relevant cultural medium and tool. This paper explores different conceptualisations of 'nature' in more than 60 languages and identifies three broad conceptual categories 1) Inclusive (i.e., human beings are an integral part of nature); 2) Non-inclusive (i.e., human beings are not an integral part of nature, implying some sort of human-nature dichotomy); and 3) Deifying (i.e., nature is defined within a spiritual realm) and concludes that ecosystem governance can be enhanced by recognising fundamental differences and a greater plurality in how nature is conceptualized across the planet (Coscieme, et al., 2020) . The promotion and consideration of multiple conceptualisation of nature based on diverse worldviews and epistemic and philosophical traditions can be achieved through mobilizing knowledge in support of culturally-sensitive initiatives for global ecosystem services governance and policymaking.

Strengths, Weaknesses, Opportunities and Threats: a SWOT analysis of the ecosystem services framework (Chapter 6)

Ecosystem Services (ES) concept has been considered one of the most prominent approaches towards conservation nowadays. Recent years have witnessed a proliferation of research on the concept with diverse framings ranging from their values (instrumental, relational and intrinsic) and the use of different assessment methods (ecological, economic, socio-cultural methods or a mixed of these), and worldviews (indigenous and local knowledge (ILK) systems). It is important to continually and critically appraise the concept – searching for gaps, suggesting how any gaps might be filled, and considering to what extent the approach remains fit for purpose in a wider context (Bull et al., 2016). The paper critically reviews the concept using a Strengths-Weaknesses- Opportunities-Threats (SWOT) analysis among Young Ecosystem Services Specialists (YESS). The analysis shows these challenges in a broader context – by providing an integrated, structured analysis of perceived strengths and weaknesses within the ecosystem services concept and its applications, as well as of the external opportunities and threats that may benefit or impede further development. Furthermore, the paper develops strategies that might overcome existing or future challenges to the Ecosystem Services concept. Some strengths identified include interdisciplinary, holistic and a useful advocacy and communication tool based on the use of the concept. Weaknesses found include the scientific basis for the approach is incomplete, the frameworks are inconsistently applied and ambiguous terminologies often applied. External opportunities presented include alignment with different existing and emerging policies and strategies, the implementation of the approach through existing tools and methods, and the possibility that environmental awareness is increasing more generally. Finally, identified external threats include general inertia regarding change in environmental practices, the broader difficulties with successful interdisciplinary collaboration, and insufficient funding to fully realise the potential of the framework. Subsequent consideration of the themes coming out of the SWOT analysis suggested five key strategic areas for enhancing the ES framework: (1) approach characteristics; (2) application of the framework; (3) effects of application; (4) demands of application; and (5) interface with the framework.

7.2 Thesis Scientific and Policy Contributions to Forest Ecosystem Services Multifunctionality

Understanding Ecosystem Services and Forest Multifunctionality

The thesis contributes to the current advances in conceptualising ecosystem services concept recognising the plural views in framings and multiple terminologies and suggests that these multiple conceptualizations are key to inclusivity and legitimacy in global forest ecosystem services governance (Coscieme, et al., 2020) highlighting the wide range of instrumental, relational and intrinsic values and the use of different assessment methods (ecological, economic, socio-cultural methods or a mixed of these), and worldviews (indigenous and local knowledge (ILK) systems).

The thesis attempts to show theoretical and empirical linkages between forest ecosystem services multifunctionality and ecosystem services concepts by determining the limitations in integrating multifunctionality in ecosystem services science. It provides evidence on how to ensure sustainable production of multifunctionality (the simultaneous provision of multiple ecosystem services and the potential to supply livelihoods). The thesis significantly reviews the current state of this rapidly expanding field and provides a hypothesis driven conceptual framework to guide the effective incorporation of forest ecosystem services multifunctionality in global ecosystem services research. In particular, it accentuates the need for incorporating livelihoods in joint production of services as well as a priori identification and explicit testing of correlations in multifunctionality as these linkages are significant for ecosystems sustainable management.

Provisioning of forest ecosystem services multifunctionality including improvement of livelihoods outcomes is highly dynamic, complex and interdependent in many diverse ways. Forest ecosystem services studies should distinctively differentiate between (1) measures of services provided and (2) consider an overall performance of an ecosystem including livelihoods outcomes which we term forest ecosystem services multifunctionality (FESM). The results confirm production of forest ecosystem services multifunctionality is potentially plausible and there is a stronger relationship between ecosystem services provisioning and livelihoods (Lambini et al., 2018; Lambini and Nguyen, 2021). Considering the rates of forest ecosystem loss and rapidly increasing human pressure on dwindling forest resources, there is a need to design and manage forest lands that can reliably provide multiple ecosystem services simultaneously. Three identified considerations and conditions identified in the thesis to ensure sustainable supply of forest ecosystem services multifunctionality are (1) securing forest institutional property rights, (2) production and cost structure estimation and (3) engaging community based conservation groups.

Methodological contributions to assessing provisioning of forest ecosystem services multifunctionality with the dual translog cost function approach in estimating the production relationship between marketed outputs and non-marketed ES in the forest sector is identified (Lambini et al., 2018). The study results in Lambini et al., 2018, show that the estimation of a cost function based on forest property data may be a powerful tool to analyse the structure of multi-output forest production and management. This method allows handling the multiple joint outputs of forest production and permits the estimation of marginal and cost complementarities in the production of multiple forest ecosystem services.

Institutional Property Rights

Secured and clearly defined forest institutional property rights can increase forest multifunctionality. The thesis outlines conceptual, analytical and theoretical aspects of forest institutional property rights with an empirical synthesis of main findings from institutional property rights effectiveness in a cross-country comparative context. It contributes to the debate on understanding of institutional quality and contexts in provisioning of forest ecosystem services multifunctionality by empirically testing forest property management and institutional arrangement outcomes. Employing Property Rights (PR) based framework coupled with some New Institutional Economics (NIE) debates on institutional property rights and linking these concepts to the Sustainable Livelihoods Framework (Lambini and Nguyen, 2014) to identify their relationship with multifunctionality. The results demonstrate that these rights impact on livelihoods and forest ecosystem services. The discussions in the thesis call for connectivity and linkages of forests institutions, property rights and forest multifunctionality since these have the potential to ensure sustainable forest resources management. The thesis calls for a "functional institution–clearly defined property right–sustainable livelihood outcome" framework in ecosystem services science. The findings as well sheds some light on the research gaps on forest institutional property rights and their linkages to sustainable livelihood outcomes which are key to sustainable forest multifunctionality management in the tropics.

Furthermore the comparative assessment of forest institutional property rights with two or more countries are relatively rare, hence the comparative exercise in this thesis provides some contributions to the usual country specific studies in the property rights literature.

Community Forestry and Forest Ecosystem Services

Community forestry is been viewed as a panacea towards promoting efficient and sustainable forest resource use and management. Often considered as a principal solution in balancing between conservation and development. In relation to the contributions on forest institutional property rights, community forestry with a clear institutional conditions and allowable forest areas for communities is a significant step towards sustaining rural communities and improving forest ecosystem management.

Despite the growing literature on community forestry in the conservation and development discourse, most studies do not consider forest multifunctionality in their impact evaluations, this thesis quantifies and assesses impact of community forestry in respect to joint supply of forest ecosystem services and sustaining household livelihoods.

The propensity score matching technique fills the methodological limitations identified and selection biases in most community forestry impact assessments. Based on the impact evaluation literature, this is the first impact assessment that applies a propensity score matching technique in finding evidence of joint ecosystem services and livelihood outcomes in conservation based groups (Lambini and Nguyen, 2021). The matching method was appropriate in comparing differences between the treated and control groups in a non-randomised setting as well as their role in provisioning of ecosystem services and household livelihoods.

The thesis develops a typology based on the literature reviewed to understand the dynamics and drivers in participating in community based conservation associations and extend impact assessments outcomes mostly restricted to forest ecosystems cover and conditions to provisioning of forest ecosystem services and livelihoods outcomes.

7.3 Thesis Limitations and Caveats

Even though research on multifuncationality in recent times is expanding, especially on how forest landscapes can be managed to deliver multiple services. The production processes of these services are highly complex based on their inherent trade-offs. Access to accurate and quality data for analysis further compounds the overall utility of the multifuncationality concept in practice and assessing their provisioning in rural areas in the tropics. This thesis attempts to address some of these research gaps and limitations and contributes theoretically and empirically to forest ecosystem services multifunctionality literature. However, this thesis has some limitations and shortcomings that need to be mentioned.

Firstly, the econometric and quantitative models applied appear to be appropriate and useful in analysing multiple joint production of forest ecosystem services and livelihoods, however, it is crucial to state that gathering adequate data on some ecosystem services outputs (forest carbon sequestration, biodiversity conservation, soil erosion control) is difficult because of the length of production processes and unequal operation costs overtime. Therefore, the study used secondary data on some missing ecosystem services outputs for example in the Kenya case study. Connected to these outputs data limitations, the models estimated used some coarse proxies to represent the growing timber stock in the forests (example forest age and size). The standing stock is an important variable that influences forest owner's long term decision making. Hence, it should be noted that the model results only apply within the range of multifunctionality outputs experienced today by forest owners. More drastic policies that imply huge increases in outputs will probably imply new management practices that are not observed today among forest owners. Such policies could not be evaluated based on the thesis results.

Secondary, the empirical field work permitted the use of cross-sectional data for most parts of the quantitative analysis, given the limitations associated with cross-sectional data, all model results were further tested for robustness and fitness. Furthermore, the mixed methods approach applied, specifically the use of participatory and qualitative field methods complimented the quantitative models used in this thesis.

Finally, even though the thesis conclusions confirm that forest ecosystem services multifunctionality can be sustainably produced based on secured forest institutions, analysis of production and cost structures and engaging forest communities, these conclusions cannot be generalised for all forest landscapes in the tropics. Further evaluations are necessary to establish these relationships in joint multiple production of ecosystem services and livelihoods.

7.4 Future Avenues

Given the complexities in the economics of production of forest ecosystem services multifunctionality. The thesis suggests further conceptual and empirical research on multifunctionality, for example through the extension of the thesis conceptual framework presented.

Clearly, there are still several gaps in knowledge and data, for example the identity of the best ecosystem services indicators, spatial and temporal patterns and clusters of livelihood options need to be addressed before confidently assessing joint production of forest ecosystem services multifunctionality.

Additional empirical research is needed to validate the linkages between forest institutional property rights, provisioning of ecosystem services and livelihoods outcomes as these institutions are fundamentally crucial in joint production processes.

Furthermore, impact assessments on community forestry should integrate ecosystem services and livelihood outcomes to further confirm our discussions on their role in multifunctionality.

Finally, the thesis confirms the call for interdisciplinary research involving ecological and economic disciplines. This is a prerequisite for more effective management of forest ecosystems, taking the provision of multifunctionality into account. There is the need to collect environmental and economic data for better evaluation of multifunctionality and a more comprehensive analysis that would account for the spatial and temporal distribution of services. Extending the interdisciplinary of forest ecosystem services multifunctionality research with an emphasis on strengthening links with the social sciences and increasing involvements from arts and humanities will offer a deeper understanding of the complexities at the intersection of the human-nature relationship.

7.5 Conclusions

Forest ecosystems provide numerous goods and services for the benefit of humans. Timber supply is the most prominent ecosystem service that is commonly considered, but there are other externalities that forest provides such as Non-Timber Forest Products (NTFPs) and soil erosion control. They are also crucial for the preservation of biodiversity as a major part of the species under pressure depend strongly on forest habitats. Forest's ability to sequester carbon is important in the mitigation of global climate change. In addition, forestry provides livelihood alternatives to numerous households and communities in developing countries. These services are widely acknowledged in contributing to the achievements of the Sustainable Development Goals (SDGs) and other international environmental agreements.

However, global forest biodiversity and ecosystem services losses are unfortunately on the rise for both natural and managed forest areas and available evidence suggests this could even increase due to human socio-economic pressures and natural hazards. Societal's demand for forest resources continues to rise and productive forest lands become increasingly scarce, remaining forest regions are at heightened risk of destruction from economic development.

Ecosystem services concept attempts to address these ecological and socio-economic crises by demonstrating human's dependence on nature and often considered as one of the most prominent frameworks towards balancing socio-economic development and conservation. Mainstreaming and implementing ecosystem services concept into policy and decision making shows significant knowledge gaps and complexities. One of the major gaps in the literature is determining how to manage multiple services at the same increasing livelihoods of providers of these services.

This thesis proposes multifunctionality production capturing joint simultaneous supply of forest ecosystem services and livelihoods as a potential scientific procedure to provide insights in ecosystem management and local landscape-scale policy. It appreciates the complex multiple interdependence between marketed and non-marketed forest services and how different management systems practiced impact on diverse production of services.

Sustainable provisioning of multifunctionality outcomes are based on the specific management actions and not directly on the change in ecosystem services or the values per -se. The thesis emphasises this role of forest management actions and the direct and indirect actions associated with ecosystem management.

Payments and subsidies for ecosystem services producers are necessary (output based instruments) but not sufficient to ensure sustainable provisioning. Hence a considerable evaluation of the structure of the production and cost of provisioning is needed in the designing and implementation of regulations and subsidies (input based instruments). Knowledge of the cost structure offers the basis for setting efficient targets for provisioning and designing cost-effective management strategies in order to meet targets, this is particularly relevant when developing instruments, where cost of provision represent the breakeven point, that is to say the minimum level of compensation forest owner could accept for undertaken the management change voluntary.

In the implementation of joint production measures and enhancing provisioning of these services, effectiveness of the present form of institutional arrangements and level of security of property rights is necessary. For example a forest owner could be given an official land title or an informal tenure agreement that specify right of access and use of the forest land. These forms of rights are relevant in the designing and implementation of management actions and thereby enhance management and increase multifunctionality.

Community based conservation associations are instrumental in the supply of ecosystem services and increasing household livelihoods sustainability. Even though there are different approaches to manage forest ecosystems, such as state enterprises, private production, co-management, protected areas, special use and community based management types among others. Community based management systems are viewed the most significant management practice in ensuring provisioning of multiple ecosystem services and sustainable livelihoods of households in forest communities in the tropics. This form of granting community access and transferring management rights empowers households and accommodates their basic needs, for example benefiting from alternative forest income generation activities.

The economics of production of forest ecosystem services multifunctionality has many potential applications. The specific conclusions drawn from the provisioning of multifunctionality based on this thesis are (a) critical assessment of forest institutional property rights; (b) rigorous cost structure of multiple production analysis; and (c) community based conservation impact assessments.

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CHAPTER 2

NATURE'S CONTRIBUTIONS TO PEOPLE AND QUALITY OF LIFE

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ORIGINAL PAPER

An economic analysis of reforestation with a native tree species: the case of Vietnamese farmers

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