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Bringing out the best of land-use policies:

An integrated coherence analysis of forestry and agricultural mitigation in Costa Rica

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Abstract

High global greenhouse gas emissions and the degradation of ecosystem services from unsustainable land use and land-use change highlight the importance of climate change mitigation activities in the forestry and agricultural sectors. Globally important examples for respective policies are *Nationally Appropriate Mitigation Activities* (*NAMAs)*, which allow developing countries to reduce sectoral emissions with international funding while considering the national context, and *REDD+*, a mechanism with a similar approach for the forestry sector. Different land-use related policies interact on various levels, causing synergies, trade-offs and adverse effects. Knowledge about their interactions is therefore indispensable in developing effective land-use policies. However, silo thinking largely confines policy analyses to individual policies. The few existing studies that analyse policy interaction, and the corresponding analytical frameworks, tend to focus on social systems, thereby omitting possible interactions between policy impacts on natural systems, including ecosystem services they provide. There is a lack of frameworks providing a holistic analysis of land-use related policies. To promote more comprehensive policy coherence analyses, I developed a methodological framework that considers interactions of all policy components from the processes to outputs and ecosystem service impacts. This proposed framework includes a content analysis of relevant policy documents, the identification and combination of components that may interact and finally interviews with officials and scientific experts. At the forefront of mitigation and conservation, Costa Rica provides a particularly interesting example for a case study of this policy coherence analysis. The country is currently implementing multiple land-use based mitigation policies, i.e. two agricultural NAMAs and a REDD+ Strategy, which were analysed regarding potential interactions. Applying the methodology revealed a large number of potential synergies, various trade-offs and few adverse effects. Despite increased collaboration between involved organisations, this study found the challenge of coordinating the policy processes of all three initiatives to mostly cause trade-offs and adverse effects, such as the risk of inconsistent carbon accounting. Policy outputs, in contrast, show a high level of coherence with many synergies between the stated policy objectives and instruments. Synergistic objectives are results of the clear prioritisation and consistent targeting of specific ecosystem services in the initiatives' and broader policy framework. Synergies between the policies' instruments often emerge from the joint extension of agroforestry systems and the national payment for ecosystem services scheme. Findings indicate that the clear prioritisation of targeted ES improves their enhancement. At the earliest policy stage, a strategic and integrated policy framework and coordination of the policy processes can facilitate coherent outputs.

Resumen

Altas emisiones de gases con efecto invernadero y la degradación de servicios ambientales (SA) que resulta de los usos del suelo y sus cambios insostenibles destaca la importancia de la mitigación del cambio climático en el sector forestal y agropecuario. Ejemplos para respectivas políticas son *Nationally Appropriate Mitigation Actions (NAMAs)*, que permiten reducir emisiones sectoriales a países en desarrollo contemplando su contexto nacional y promoviendo fondos internacionales, y *REDD+*, lo cual es una iniciativa similar para el sector forestal. Diferentes políticas relacionadas al uso de la tierra interactúan en varios niveles, causando sinergias, conflictos y efectos adversos. Por lo tanto, conocimiento de estas interacciones es indispensable para garantizar la efectividad de esas políticas. Sin embargo, análisis mayormente están limitadas a políticas individuales. Las pocas investigaciones que analizan interacciones de políticas tiendan centrarse en sistemas sociales, omitiendo posibles interacciones en nivel de los SA afectados por las políticas, situación que limita la utilidad para políticas relacionadas al uso del suelo. Para fomentar análisis integrales de coherencia de políticas, se desarrolló un marco metodológico como parte de esta tesis que permite tomar en cuenta interacciones de todas las componentes de las políticas, incluyendo el proceso, los resultados (objetivos, instrumentos y prácticas de implementación) y los impactos sobre los SA. El marco sugerido contiene un análisis de contenido de documentos normativos pertinentes, la combinación de componentes identificadas para exponer sus interacciones y ultimadamente entrevistas con expertos funcionarios y científicos. En la vanguardia de conservación y mitigación, el contexto normativo de Costa Rica constituye un ejemplo particularmente interesante para un estudio monográfico de este marco analítico de coherencia de políticas. El país está implementando dos NAMAs agropecuarios y una estrategia REDD+, los cuales fueron analizadas respeto a posibles interacciones. Resultados revelaron muchas sinergias, varios conflictos y pocos efectos adversos. A pesar de la colaboración aumentada entre organizaciones involucradas, se observó que coordinar los procesos políticos de las tres iniciativas mayormente causa conflictos y efectos adversos como por ejemplo el riesgo de la contabilidad inconsistente de carbono. En cambio los resultados de las políticas muestran un alto nivel de coherencia con muchas sinergias entre los objetivos y los instrumentos. Objetivos sinérgicos están basados en la priorización clara y focalización consistente de SA específicos en todas las iniciativas y en el marco normativo. Sinergias de instrumentos a menudo emergen de abordar en conjunto la extensión de sistemas agroforestales y el programa nacional de pagos por SA. Los hallazgos indican que una clara priorización de SA abordados facilita mejorarlos. Un marco político estratégico e integrado tanto como la coordinación de la formulación de políticas lo antes posible aumenta la coherencia de los resultados normativos.

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Acronyms and abbreviations

AFOLU: Agriculture, forestry and other land use
AFS: Agroforestry systems
CATIE: Centro Agronómico Tropical de Investigación y Enseñanza (Tropical Agricultural Research and Higher Education Center)
CNFG: Concepto NAMA Fincas Ganaderas (Livestock Farms NAMA Concept)
EGBC: Estrategia de Ganadería Baja en Carbono (Low Emission Livestock Strategy)
ENREDD+: Estrategia Nacional de REDD+ Costa Rica (National REDD+ Strategy)
ES: Ecosystem services
FCPF: Forest Carbon Partnership Facility
GHG: Greenhouse gases
ICAFE: Coffee Institute of Costa Rica (Instituto del Café de Costa Rica)
LNC: Livestock NAMA Concept
MAG: Ministerio de Agricultura y Ganadería (Ministry of Agriculture)
MINAE: Ministerio de Ambiente y Energía (Ministry of Environment and Energy)
NAMA: Nationally Appropriate Mitigation Action
NGCR: NAMA Ganadería Costa Rica (Livestock NAMA Costa Rica)
PES: Payment for ecosystem services
PI-ENREDD+: Plan de Implementación de la Estrategia Nacional REDD+ Costa Rica (REDD+ Implementation Plan)
PND: Plan Nacional de Dearrollo 2015-2018 "Alberto Cañas Escalante" (National Development Plan)
PPSA: Programa de Pagos por Sevicios Ambientales (Payment for Ecosystem Services Programme)
REDD+: Reduce Emissions from Reforestation and Forest Degradation, and Foster Conservation, Sustainable Management of Forests, and Enhancement of Forest Carbon Stocks
REL: Reference emission level
SIMOCUTE: Sistema de Monitoreo de Cobertura y Uso de la Tierra y Ecosistemas (System for the Monitoring of Land Cover, Land Use and Ecosystems)
SPS: Silvopasture systems
UNFCCC: United Nations Framework Convention on Climate Chang

1. Introduction

1.1 Problem description

Agriculture, forestry and other land use (AFOLU) describes a category of human activities responsible for almost a quarter of total anthropogenic greenhouse gas (GHG) emissions (Smith et al., 2014). The categorisation originates from the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National GHG Inventories (Paustian et al., 2006) and has since been widely adopted to integrate into one sector all GHG emissions and removals from managed land (e.g. Leip, Carmona-Garcia, & Rossi, 2017; Tubiello et al., 2015). In the AFOLU sector, main sources of carbon dioxide emissions include deforestation and forest degradation[1], whilst emissions of other GHGs such as nitrous oxide and methane result mostly from agricultural practices (Smith et al., 2014). Given the large share of the sector in global GHG emissions, efforts to reduce AFOLU emissions are a very important component of climate change mitigation (Bustamante et al., 2014). Beyond emission reductions, AFOLU provides potential to remove carbon from the atmosphere and sequester it in soil and biomass, which makes the sector particularly interesting for mitigation policies. Economies that largely rely on land-use based activities, which is often the case in developing countries, find high potential for their national contributions to global mitigation in the AFOLU sector.

Apart from options for AFOLU emission reductions on the demand side, such as minimising food waste or changing consumption patterns (Smith et al., 2014), diverse mitigation options exist for the supply side, i.e. emission reductions in land management. Different scholars have identified a variety of AFOLU mitigation options, an overview is provided by Bustamante et al. (2014) (see table 1).

Table 1: Mitigation options in the AFOLU sector (Bustamante et al., 2014).

Categories	**Mitigation options**
Forestry	Reducing deforestation
	Afforestation/reforestation
	Forest management
	Forest restoration
Land-based agriculture	Cropland management of plants, nutrients, residues, water, etc.
	Grazing and land management of plants, animals, fire
	Revegetation
	Restoration of organic soils
	Biosolids application
Livestock	Livestock feeding
	Livestock breeding and other long-term management
	Manure management
Integrated systems	Agroforestry and silvopasture systems
	Other mixed biomass production systems

[1] Forest degradation has been "defined as a loss of biomass density without a change in the area of forest cover" (Olander, Gibbs, Steininger, Swenson, & Murray, 2008, p. 2) and in the Costa Rican context it is described as a significant loss of carbon in areas defined as mature forest due to human activities (MINAE, 2015).

	Integration of biomass production with subsequent processing in food and bioenergy sectors

Many options are now being implemented in developing countries as instruments of policies that enable international funding. Flexible implementation of different options is possible through land-use based Nationally Appropriate Mitigation Actions (NAMAs), while more stringent forestry-related activities can be implemented as “reductions in GHG emissions from deforestation and forest degradation, conserving and enhancing forest carbon stocks and sustainably managing forests” (REDD+) (Corbera & Schroeder, 2011, p. 89). For the resulting verified emission reductions, carbon credits can be generated and sold internationally, thereby enabling cost-efficient emission abatement with potentially high benefits for sustainable development.

As will be discussed in chapter 2, land-use NAMAs and REDD+ are arguably the two most important AFOLU mitigation mechanisms for the developing world. Although there is high potential for land-use NAMAs and REDD+ to interact if both are implemented nationally, the development of NAMAs and REDD+ through the United Nations Framework Convention for Climate Change (UNFCCC) occurred largely separated (van Noordwijk, Agus, Dewi, & Purnomo, 2014). While this allowed for advances in the REDD+ negotiations despite slower progress on NAMAs, the separation led to two formally distinct mechanisms, each with specific characteristics and requirements.

The coordination of AFOLU mitigation policies requires aligning policy processes and outputs while safeguarding important ES. Various ES may deserve special attention in the policy context due to their importance for climate change mitigation, adaptation and sustainable development. It is generally possible to opt for multiple AFOLU mitigation policies, which has been done by various developing countries. However, different policies can interact and affect each other’s effectiveness (Nilsson et al., 2012). Policies can interact on different levels and in different ways, and effectiveness in terms of delivering expected outcomes results from mechanisms that are equally complex. Beyond interacting processes and outputs, outcomes from (the interplay of) multiple AFOLU mitigation policies impact interactions between naturally interconnected ES.

To optimise interactions between land-use policies on the national level, implementing countries thus need to guarantee an appropriate level of policy integration. Integrating policies to account for possible interactions is a challenging task that can be vital for the success of the policies. The examination and optimisation of potential policy interactions relies on knowledge about the underlying processes. For instance, reducing land-use based emissions requires understanding of the linkages and policy levers between agriculture and forestry (ibid). As an integrated approach to mitigation in the different economic sectors, implementation of land-use NAMAs and REDD+ within a national policy framework also requires deep understanding of ecological and socio-economic processes.

It is very important to note that AFOLU mitigation options have significant impacts on natural ecosystems beyond the mitigation of climate change. Mitigation in the form of carbon sequestration through biomass production can, in fact, be regarded as one of many vital ecosystem services (ES) that land provides. Generally, AFOLU mitigation policies are very likely to have impacts on the provision of ES (Smith et al., 2014) by influencing management practices of land and forest resources. Such policy impacts on ES are highly context dependent. Different landscapes provide specific sets of ecosystem services that interact in complex and dynamic ways (Bennett, Peterson, & Gordon, 2009), including supporting, regulating, provisioning and cultural services.

For example, a synergy between ES impacts can occur where one policy aims to improve water quality by reducing pesticide use while another promotes afforestation for carbon sequestration, since afforestation can also contribute to improved water quality. As an example for a trade-off between policy outputs, one policy instrument may increase agricultural profitability and lead to area expansion, while another policy aims to address agriculture as a driver of deforestation. In some cases, interaction between policies can have a negative impact on the effectiveness of both policies, which then constitutes an adverse effect. An excessively complex integration process, for example, can cause confusion among the involved policy makers and “waste” their capacities at the expense of the individual policies.

The identification of such interactions is important to inform the development of more effective AFOLU policies. Figure 1 outlines how AFOLU policy interactions emerge and how they create new tasks for policy makers and scholars.

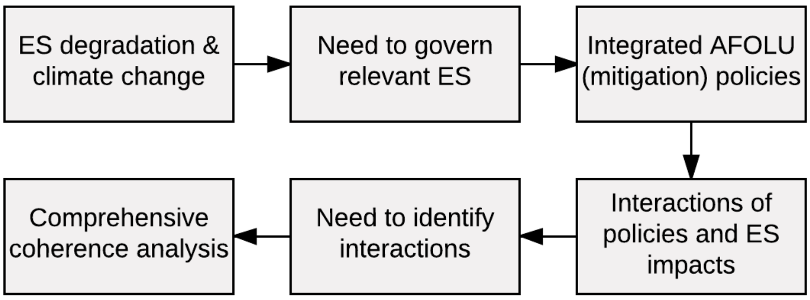

Figure 1: Line of reasoning for the need to address AFOLU policy coherence.

In Latin America, relative emissions in the AFOLU sector are particularly high (Calvin, Beach, Gurgel, Labriet, & Loboguerrero Rodriguez, 2016). Therefore, Costa Rica is implementing a National REDD+ Strategy (Estrategia Nacional REDD+ Costa Rica, ENREDD+) and at the same time two NAMAs for a low-carbon coffee and livestock sector. These are important agricultural sectors in the region and are closely linked with forestry through their association with agroforestry. Interactions between REDD+ and the two NAMAs will likely impact the provision of ES by forests or farms, such as carbon sequestration and water regulation. Implementing both a REDD+ strategy and land-use NAMAs poses many challenges regarding their integration (Costenbader, Pritchard, Galt, & Stanley, 2013).

Considering the complexity of ecological and socioeconomic systems (Limburg, O’Neill, Costanza, & Farber, 2002), their interactions may escape the awareness of policy makers and thus challenge effective governance. Based on the notion of policy coherence, the effective implementation of multiple AFOLU mitigation policies requires awareness and exploitation of synergies. However, it is important to also consider the risk of policy instruments undermining each other’s objectives (Oikonomou & Jepma, 2008) and ultimately their effectiveness. These challenges add to the fact that the field of climate change mitigation already is a policy crowded environment (ibid), where a relatively large amount of policy processes and outputs potentially interact.

Increasingly, integrated approaches to ES management, including land-use based mitigation, through AFOLU measures are developed and exchanged, seen for instance with climate-smart agriculture. However, there is no explicit focus on interactions across approaches or landscapes, let alone a framework for systematic analyses thereof. Although specific AFOLU policies, such as NAMAs and REDD+ strategies, are formulated and implemented by governments, there is little knowledge about interactions of national AFOLU policies.

The knowledge gap regarding AFOLU policy interactions and how to examine them is an issue in general and in particular for countries to successfully combine the implementation of land-use NAMAs and REDD+. Costenbader et al. (2013) assert that the coordination of NAMA and REDD+ activities at the national level is vital. They recognize a "lack of clarity on how these relate to each other and what could be possible implications of integrating them into a coherent national strategy towards climate change mitigation" (ibid, p. 3). Since international REDD+ negotiations are more advanced than those of NAMAs (ibid), there is an imbalance in literature on the two mechanisms. REDD+ is perceived as one of the most visible current AFOLU policies for cost-effective mitigation, with many possible socioeconomic and ecological co-benefits (Smith et al., 2014). However, there is still insufficient understanding about the interactions of REDD+ with national or local goals, which is considered to be a key variable in the future effectiveness of REDD+ activities (Corbera & Schroeder, 2011). National or local goals that may interact with REDD+ implementation include for instance sectoral and environmental objectives, which are both expressed in NAMAs. A cross-sectoral approach to forest loss through REDD+ initiatives, for instance, must explore interactions with agriculture as a driver of deforestation (Kalaba, Quinn, & Dougill, 2014). Deforestation, agriculture and ES (including climate regulation) are very closely linked, which should be reflected in respective policies. More generally, synergies and trade-offs between REDD+ goals, livelihoods and alternative land uses must be better understood (Phelps, Webb, & Agrawal, 2010). The same is relevant for land-use NAMAs, because they, too, cause various interactions that need to be identified in order to manage them and avoid losses in their effectiveness.

The described policy problem emerges from the practical implementation of multiple AFOLU (mitigation) policies. It was therefore addressed through a practice-oriented problem analysis, using the two mitigation mechanisms in Costa Rica as a case study. Nevertheless, the methodology and analysis I present in this thesis also makes contributions of theoretical relevance.

1.3 Research objective

This study aimed to (1) develop an analytical methodology that allows to identify interactions between AFOLU policies, including interactions among their ES impacts; (2) test its practical usefulness by examining potential interactions between policy processes, outputs and affected ES resulting from the implementation of the Costa Rican Coffee and Livestock NAMAs, and policies and measures under REDD+; (3) identify mechanisms that may cause these interactions in a national context; and to (4) distil practical lessons learned as well as policy recommendations for the wider region of Latin America and the Caribbean, based on insights from applying the framework. Those objectives will help expand current theories and inform policy makers in the difficult task of integrating sectoral policies.

1.4 Research questions

From the assumption that AFOLU mitigation policies can interact in different ways due to their functional and spatial overlap, I derived the underlying hypothesis:

If the Costa Rican NAMAs for low-carbon coffee and livestock production are implemented simultaneously with the ENREDD+ (independent variables), then synergies and trade-offs (dependent variables) between them occur.

Based on this hypothesis, the central research question was formulated as follows:

1. *What are potential interactions between the Costa Rican Coffee and Livestock NAMAs and the National REDD+ Strategy and Implementation Plan, and between their impacts on ES?*

Three sub-questions were formulated to facilitate the analysis and increase the usefulness of expected results:

2. *What is a useful methodology to examine complex interactions between AFOLU (mitigation) policies?*
3. *What is the role of the broader policy context in creating and exploiting synergies and minimising trade-offs and adverse effects?*
4. *What are lessons learned from this specific case that may inform the implementation of similar policies in countries of Latin America and the Caribbean?*

1.5 Relevance

1.5.1 Scientific relevance

Scientific contributions of this research are twofold, including theoretical considerations of AFOLU policy interactions in general and the proposition of a methodological approach to identify them.

Bennett et al. (2009) identify in most science the implicit assumption that there are no significant ES interactions. Such interactions should be taken into consideration to get a realistic idea of the policy impacts. This particularly the case when multiple policies are involved with interacting impacts on ES. The important role of policy interactions and limited knowledge on interactions between ES in a national policy context gives rise to the need for policy analyses of AFOLU mitigation options that take a broad interdisciplinary and cross sectoral perspective. Scholars in the field may thus improve the quality and usefulness of their research with a wider scope to include synergistic and conflicting interactions with other land-use policies and their ES impacts. At the moment, an interdisciplinary methodology to analyse these complex interactions is lacking. To address this gap in literature, I developed and tested such a comprehensive framework, based on the combination of different specialised approaches from existing literature. The framework can be applied in various policy contexts in order to identify interactions between AFOLU mitigation options on different layers from objectives to ES impacts.

For scholars to effectively contribute to the improved governance of urgently needed ES for mitigation, adaptation and sustainable development through AFOLU policies, knowledge about interactions of and policy impacts on ES is required. Bennett et al. (2009) note that “we don’t know much about when to expect trade-offs or synergies [between ES], the mechanisms that cause them, or how to minimize trade-offs and enhance synergies” (p. 1395). The conducted case study of interactions between Costa Rica’s AFOLU mitigation policies revealed general interactions of the policies and in particular provides important knowledge on interactions among nationally prioritised ES that may be affected by the policies.

Research on policy interactions has mostly been focused on international policies (Kalaba et al., 2014). And although environmental and climate policies have been much discussed, their interactions are not sufficiently explored. Only few studies have dealt with the interactions between different mitigation policies, and they mainly confined the methodology to the analysis of two specific measures. Despite being recognized as a key issue for success, the interactions of policy instruments have received little attention. (Oikonomou & Jepma, 2008) Data and knowledge gaps include the understanding of the interplay of AFOLU mitigation choices, e.g. improved agricultural management, forest conservation and afforestation on the national scale (Smith et al., 2014). By adding to the body of literature on AFOLU policy interactions and providing a tool for additional research on this field, the present study will contribute to closing those research gaps.

1.5.2 Societal relevance

Generally, growing interest has been noted among policy makers in understanding the processes of policies influencing each other’s effectiveness and the resulting challenges and opportunities (Kalaba et al., 2014). For AFOLU policies, the interactions that exert this influence also occur where the policies affect interacting ES. Knowledge about the ES relationships can therefore improve our ability to manage trade-offs and synergies between ES impacts (Bennett et al., 2009). Exploiting synergies and reducing trade-offs between the policies and their ES impacts is key in increasing policy effectiveness and efficiency. For that reason, decision makers first require knowledge about potential trade-offs, both between sectors (Smith et al., 2014) and within sectors (Bustamante et al., 2014). The recognition of trade-offs is equally important in discussions about multiple benefits. Expectations of win-win scenarios with no losses risk causing disappointment if they are not fully met. In the long term, this can erode trust and the goodwill required for conservation efforts (Hirsch et al., 2011). In their review on policy coherence in several European countries, Mickwitz et al. (2010) notice a general tendency to conceal trade-offs between mitigation policies and other aims, whereas potential synergies are being highlighted. This study paid equal attention to detrimental interactions, revealing unknown trade-offs and adverse effects.

Managing forests with multiple objectives, such as water availability, local and global climate regulation, carbon sequestration and food security, requires improved policy coherence (Ellison et al., 2017). Coherence of any new AFOLU mitigation strategy with other policies is a prerequisite for its successful implementation (Smith et al., 2014) and for sustainable development in general (Kalaba et al., 2014). NAMAs and REDD are arguably the most important recent initiatives in developing an international climate agreement (Costenbader et al., 2013). Costa Rica's internationally recognised conservation efforts, its pioneering Payment for Ecosystem Services Programme (Programa de Pagos por Sercivios Ambientales, PPSA) as foundation of the ENREDD+ (see subchapter 2.2.2) and the first agricultural NAMA implementation worldwide (see subchapter 2.2.3) make their interactions a particularly interesting case for a coherence analysis of AFOLU mitigation policies. This relates to a special role of ES in the context of Costa Rica, which is discussed in Appendix 1 (chapter 8.1; 8.2).

Findings from this innovative policy analysis of current efforts and progress in the implementation of REDD+ and land-use NAMAs can inform the development of diverse AFOLU policies to come. Beyond offering lessons learnt and recommendations to both policymakers and supporting actors in the Costa Rican policy process, the information generated can be useful to all interested actors developing similar AFOLU policies in other countries of Latin America and the Caribbean. New insights can be used to maximise synergies and minimise trade-offs, thereby providing additional benefits to society in the form of enhanced ES and more effective climate change mitigation.

1.6 Research framework and outline

This research was conducted through an iterative process that combined information from different sources. Figure 2 presents a schematic visualisation of the research framework showing how the described problem was approached. Starting point was a literature review to establish the theoretical foundation for the analysis. This encompassed the concepts of policy coherence and ES as well as general considerations for NAMAs and REDD+. Insights gained thereby led to the development of a conceptual framework that serves to frame interaction problems for their analysis. This lens guided the subsequent development of methods for data collection and analysis, including multiple content analyses and interviews for the specific policies at hand, which answered sub-question 2. The methodology was applied to the case study to identify potential interactions between the policy processes, outputs and affected ES. Through content analyses and interviews, interactions were identified and cross-checked with theoretical and empirical knowledge from literature. After their verification in additional interviews, a final compilation of specific interaction was created that answers sub-question 1. Linking these findings to the broader policy framework allowed conclusions about the role of the institutional context, leading to the answer of sub-question 3. Finally, all findings were examined for general lessons learnt from the Costa Rican case and distilled into specific policy recommendations on how to exploit synergies and reduce trade-offs.

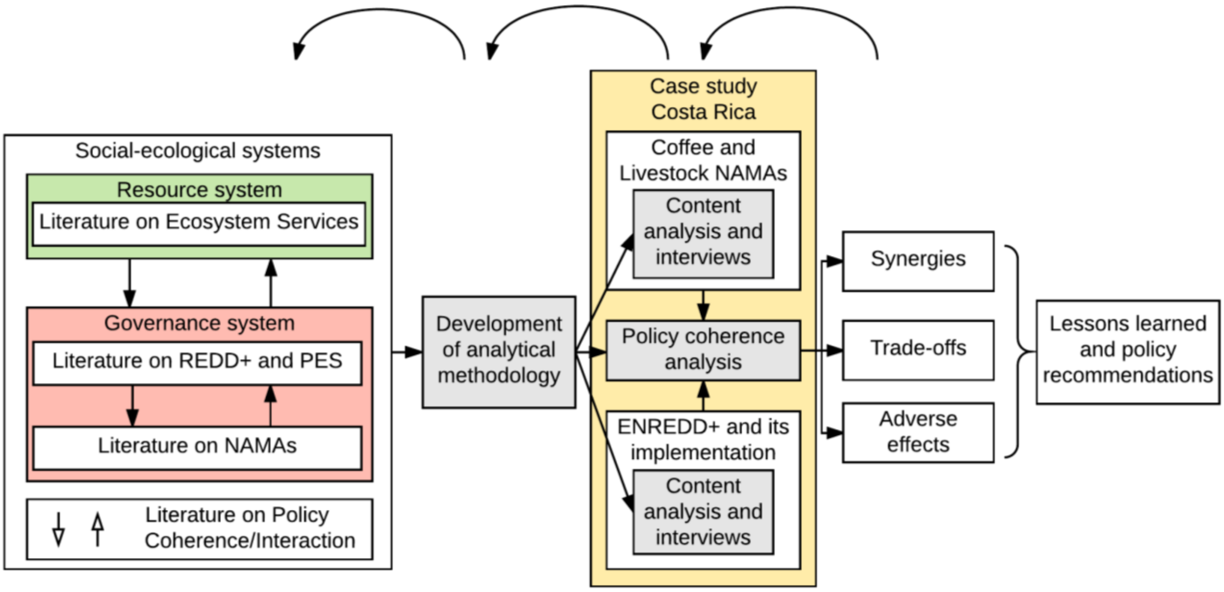

Figure 2: Research framework of this thesis.

Despite the iterative process of conducting this research, the following report is structured in a rather linear way throughout and within chapters. First, the following chapter 2 builds on a literature review to provide context information, elaborate on current theories and concepts, present relevant policy mechanisms, resulting in a conceptual framework for the analysis. Chapter 3 describes the analytical methodology that was developed based on findings from literature and specific requirements of the research objectives. In chapter 4, results of the case study applying the methodology are laid out and linked back to academic and grey literature. In chapter 5, I conclude by answering the research questions posed above. Finally, the results are discussed in chapter 6 in the light of recent literature and a list of lessons learnt and policy recommendations is given.

2. Literature review: ES governance through AFOLU policies (in Costa Rica)

2.1 Ecosystem services

The concept of ecosystem services is "commonly defined as the benefits humans derive from functioning ecosystems" (Ellison et al., 2017, p. 58). In the light of a growing world population and worsening human impacts on the environment, such as land degradation, biodiversity loss and climate change, the demand for nearly all ecosystem services (ES) is increasing (Bennett et al., 2009). Those include cultural services (e.g. aesthetic values/scenic beauty) supporting services (e.g. nutrient recycling), provisioning services (e.g. freshwater, food and fibre) and regulating services (e.g. pest control, erosion regulation, water regulation, water purification, pollination and carbon sequestration) (Millennium Ecosystem Assessment, 2005).

Climate change mitigation through carbon sequestration (more broadly referred to as climate regulation) as a regulating service is just one of many ES that are vital to human wellbeing (Smith et al., 2014). Through land-use change in forestry and agriculture, many ecosystems are being largely altered and engineered to produce only very specific ES more efficiently. These desired ES are mainly provisioning services from agricultural production (Bennett et al., 2009; Rodríguez et al., 2006). Natural ecosystems such as forests are converted into farm land, but also the use of existing farm land is further intensified. The resulting ecosystem on farms can be referred to as agroecosystems, which vary in scale, ranging from within one farm to a collection of several farms. Power (2010) observes that agroecosystems, just like natural ecosystems, can both consume and provide a variety of ES (see figure 3), depending on the management strategy. They make use of some ES like pest control or pollination and provide others like the production of food and fibre. Some management practices can improve regulating services that in turn increase provisioning and cultural services (Bennett et al., 2009; Power, 2010), for instance by facilitating pollination of crops through favourable insect habitats and thereby enhancing food production. Other practices cause the reduction of ES, which is seen on monocultures reducing natural pest control. Reduced pest control may negatively affect provisioning services, another example for the close relationships between different ES.

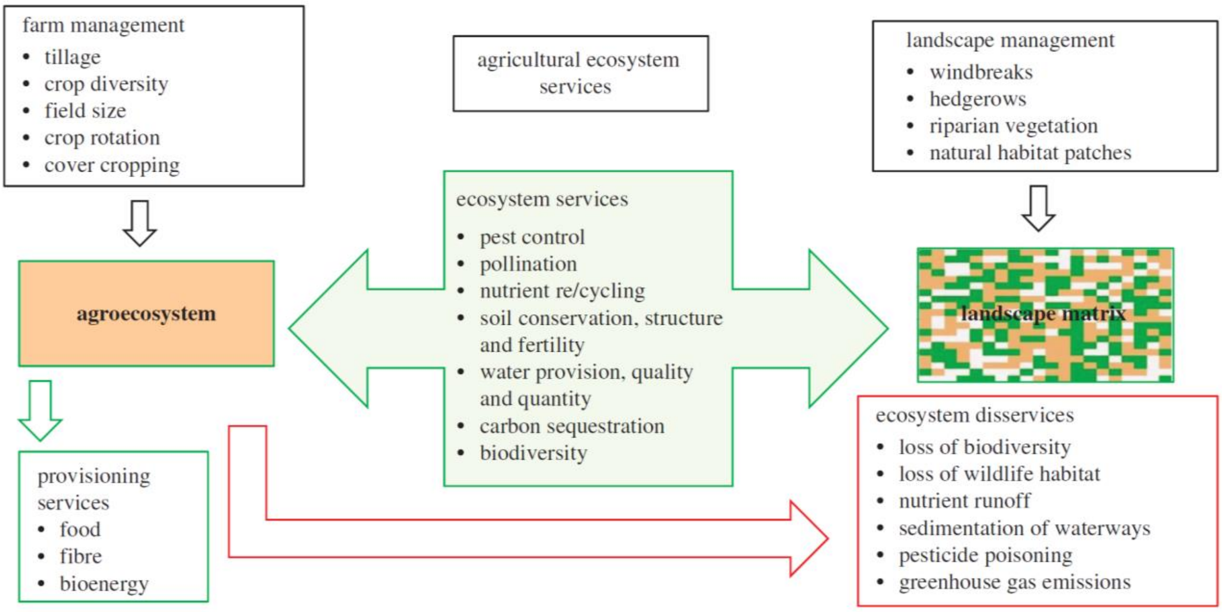

Figure 3: Impacts of farm management and landscape management on the flow of ecosystem services and 'disservices' (impaired ES) to and from agroecosystems (Power, 2010).

As suggested by Bennett et al. (2009) we can distinguish between two mechanisms that link different ES. Firstly, there are naturally occurring interactions among ES, for example carbon sequestration in plants being linked to the production of fibre. Secondly, a common driver can affect various ES, which is observed when the use of fertilisers affects both food production and water purification. Relationships between interacting ES are either unidirectional (e.g. pollination enhancing food production) or bidirectional (e.g. erosion control and the production of fibre can be mutually beneficial). Interaction can furthermore be defined though either positive correlation, as described in the last two examples, or negative correlation, for instance increased food production decreasing water availability through higher evapotranspiration (ibid).

As this chapter highlighted, the concept of ES is very useful to frame human benefits derived from natural land and the impacts our activities have on them. Due to a narrow focus as well as the negligence of their spatial concordance and interconnectedness when favouring certain ES, many land-use activities are causing undesirable declines or the complete loss of other ES

(Bennett et al., 2009). Too often these valuable services are lost as a result of lacking incentives to preserve them (Global Environment Facility, 2005). In fact, according to the Millennium Ecosystem Assessment (2005), 60 percent of all examined ES are being degraded or used in an unsustainable manner despite the fact that the human species is “fundamentally dependent on the flow of ecosystem services” (p. V). It is thus very important to note the key role of (interacting) ES in the global environmental and climate crisis as well as governance thereof.

2.2 Governance of ES

Effectively governing ES requires policies to incentivise changes in land management, i.e. on-the-ground practices that affect landscapes and ecosystems, including clear objectives for the enhancement of specific services. However, with governance and management approaches often attempting to control key ecosystem variables for a more efficient and reliable delivery of ES, the systems' vulnerability to unexpected changes increase (Olsson et al., 2006). Trade-offs between ES and their highly non-linear interdependency poses the main challenge in their management (Rodríguez et al., 2006). In general, directly increasing the use of provisioning services (for which there mostly is a market) tends to conflict with safeguarding the supporting, regulating and cultural services (which mostly do not have a market value). These trade-offs are often unintended and not a result of deliberate governing (Bustamante et al., 2014; Makkonen, Huttunen, Primmer, Repo, & Hildén, 2015; Rodríguez et al., 2006). This is particularly problematic since urgently needed climate change mitigation largely requires the provision of regulating services, i.e. climate regulation through the carbon and water cycles (Ellison et al., 2017). An important task for decision makers is therefore to reduce trade-offs and exploit synergies in the management of ES.

There is a growing corpus of literature that examines the effects of land use and land-use change on the provision of multiple ES. Increasing knowledge about ES as means for mitigation and adaptation led to a stronger focus on ecosystem management in sustainable development (Bustamante et al., 2014). Although few studies examine interactions among more than two ES, important relationships between and within ecosystems have been found. Understanding how multiple ES are affected through interactions or common drivers can help identify efficient management investments that yield substantial ecological benefits (Bennett et al., 2009) and protect vital ES. Particularly countries on a sustainable development path may consequently benefit from land-use related governance efforts that consider policy impacts on interacting ES. This chapter shows the necessity to actively govern ES and consider their interactions that affect relevant policy outcomes. Results of this research will link the current knowledge about ES interactions to possible policy impacts on these services, highlighting how policies interact on the level of ES.

2.2.1 Forest cover and ES

Forests play a key role in the provision of ES on global, regional and local scales, the governance of ES is thus inextricably linked with the governance of forests. In a literature review on the role of forests for water and climate regulation, Ellison et al. (2017) assert that the “ecosystem services concept has helped broaden the framing of decision-making on ecosystems from a focus on tangible products to a more inclusive consideration of ecosystem functions and their services” (p. 58). The conservation and restoration of forests and the ES they provide, as a cost-effective means of climate change mitigation (Bustamante et al., 2014; Canadell & Raupach, 2008; Gullison et al., 2007) with various co-benefits, has recently received a lot of attention in the international policy arena.

Since the forest definition of the UNFCCC leaves it to countries to choose a threshold canopy cover for forests between 10 and 30 percent, policies targeting agroforestry can be formally included in forestry and in international mitigation mechanisms such as REDD+. Agroforestry systems (AFS) employ practices that integrate trees in agricultural areas (Minang, Bernard, van Noordwijk, & Kahurani, 2011). This concept includes trees on areas used for livestock farming, which will henceforth be distinctly referred to as silvopasture systems (SPS). Incentivising AFS and SPS is an important policy instrument for the governance of ES in tropical regions. Agroforestry and silvopasture has therefore been described as means for climate change mitigation and adaptation (García-Rangel et al., 2017) or for enhancing certain ES (de Clerck et al., 2011). Those functions mostly overlap, since mitigation and adaptation using agroforestry and silvopastures is based on their enhancing impacts on multiple ES. Services that can be enhanced through the implementation of AFS include carbon sequestration, water regulation, water purification, biodiversity conservation, erosion control and food production (Beer et al., 2003). Furthermore, the forestry component in agricultural systems can increase soil fertility (ibid) and soil organic matter (Smith et al., 2014). These contributions to soil conservation have also been linked to enhanced carbon stocks in the soil (World Bank, CIAT, & CATIE, 2015). SPS have been reported to enhance the same ES as mentioned above (de Clerck et al., 2011).

Costa Rica is a tropical country with a unique history of ES conservation, as the following subchapter will demonstrate. Its tropical forests provide vital ES from local to national scale and are part of the world’s most important biodiversity reservoirs (García-Rangel et al., 2017). The maintenance and enhancement of ES in Costa Rica is thus very closely bound to the governance and management of forests. Climate regulation, as the primary ES targeted by AFOLU mitigation policies, in the Costa Rican forestry sector has estimated abatement costs of US$7 per ton of CO_2, which is much lower than estimates (US$73 to US$166) for the national energy sector (MINAE, DCC, AECID, & EPYPSA, 2012). Like forests, AFS and SPS also have a high importance in Costa Rica’s land-use context. Such tree-based production systems can serve to sustainably intensify and diversify agricultural production while enhancing ES and local livelihoods. Furthermore, they can maintain forest carbon stocks if the produced timber replaces illegal extraction from nearby forests. (García-Rangel et al., 2017)

Forest and tree-based production systems can consequently play an important role in the governance and management of ES beyond climate regulation. Understanding how trees enhance the provision of specific ES is key to be able to examine interactions of policies that aim to enhance them, given that it is a major underlying mechanisms. Analogously, the case study of Costa Rica relies on an understanding of the ES derived from trees and forests.

2.2.2 Payment for ecosystem services and REDD+

Most ES, including those provided by forests, can be considered externalities since they provide benefits that do not have a natural market and are thus generally not part of economic decisions (Costanza et al., 1997). Vignola, Locatelli, Martinez, & Imbach (2009) assert that due to market failures "current regulations fail to conserve ecosystem services that are valuable for society" (p. 693). The general idea of payment for ecosystem services (PES) schemes is the conservation of ES through voluntary payments from their 'consumers' to their 'producers'. This is hoped to have the co-benefit of poverty alleviation in rural areas, where land-management practices strongly affect ES. These initiatives are driven by a wide range of actors from governments to public-private partnerships and differ in their mechanisms for the monitoring of ES and the formation of prices. (Kosoy & Corbera, 2010)

The most important international mechanism that largely relies on the concept of PES is REDD+. The initiative aims to help developing countries protect and sustainably manage their forest resources for climate change mitigation and additional environmental and social co-benefits. The mechanism creates a financial value of additionally stored carbon in biomass and soil (ibid). Because these forest carbon stocks are not traded like conventional, material goods such as timber, their market is solely policy-driven. By signing the UNFCCC agreement in 1992 and ratifying the Kyoto protocol, a market demand for carbon sequestration as an ES was created (Makkonen et al., 2015). In 2005 at the Conference of the Parties in Montreal, UNFCCC negotiations on REDD+ began and continued throughout the following Conferences.

Using Costa Rica as a case study provides a unique example for the governance of ES through PES. Long before the UNFCCC negotiations, Costa Rica had introduced a pioneering market-based instrument to counteract deforestation and the loss of ES. This PPSA is widely considered the most successful application of the ecosystem services approach to environmental management globally (Global Environment Facility, 2005). More details on the history of the PPSA can be found in Appendix 1 (chapter 8.3). An extension of the PPSA constitutes the backbone of Costa Rica's national REDD+ efforts. The country's ENREDD+ and Implementation Plan (Plan de Implementación de la ENREDD+, PI-ENREDD+) constitute important new steps in Costa Rica's governance of ES.

Not only in Costa Rica but many other tropical developing countries, PES schemes and REDD+ activities represent key efforts in the governance of ES. A basic understanding of the underlying political and economic mechanisms, as described here, facilitates the analysis of these important AFOLU policies.

2.2.3 Nationally Appropriate Mitigation Actions

NAMAs are other important components in the national governance of ES if implemented in agricultural sectors. The mechanism can be seen as one consequence of the Assessment Report 4 by the IPCC, which stated the need for developing countries to achieve substantial deviation from their business as usual emissions. The UNFCCC recognizes that mitigation actions by developing countries should match their respective capabilities. This means that their social and economic development, in contrast to developed countries, remains the first priority and all mitigation actions should be taken in the context of sustainable development. NAMAs should furthermore be supported by developed countries through technology, financing and capacity-building. Developing countries can also rely on their own resources for NAMAs to get recognition for generated reductions of global GHG emissions. Equal to REDD+, international recognition of mitigation efforts from NAMAs requires planning and implementation to take place in a measurable, reportable and verifiable manner. The added value of NAMAs is to get beyond the narrow scope of project-based mechanisms, since their broader scope may allow to capture synergies among a multitude of different actions. (Sharma & Desgain, 2013)

The conversion of natural ecosystems, and of the ES they provide, is or was to a large extent based on the growing global demand for commodities with high income elasticity, such as coffee and beef (Lambin et al., 2014). Such productive systems are not only responsible for the loss of ES, but also for high GHG emissions. In Costa Rica, the coffee sector accounts for 9% of total national GHG emissions (Nieters, Grabs, Jimenez, & Alpizar, 2010) and the Livestock Sector contributes 23.6% of total emissions (MINAE, 2014). Owed to the relatively high emissions, coffee and livestock farming are two of the currently five sectors that have been targeted by the Costa Rican government for climate change mitigation through NAMAs. Abatement costs in Costa Rica's agricultural sector are estimated at US$25 per ton of CO_2 (MINAE et al., 2012). Since the two sectors cover a large proportion of Costa Rica's land area, the Coffee and Livestock NAMAs offer potential to enhance the provision of many ES beyond carbon sequestration. The two specific NAMAs at hand are particularly interesting for ES governance because of their link with forestry through AFS on coffee farms and SPS on livestock farms. As the globally first agricultural NAMA to be implemented, the Coffee NAMA takes a pioneer role in climate mitigation. Furthermore, the generalizable character of the coffee and livestock sectors provides an interesting case for other mitigation policies in Latin America and the Caribbean with similar agroecosystems.

Allowing the transformation of entire land-use sectors, this important global initiative provides countless opportunities to interact with other AFOLU policies. Like the subchapter on PES and REDD+, the information on (agricultural) NAMAs provided here helps understand the basic concept of this initiative, which in turn facilitates the development and application of methods to analyse its coherence with a national policy context.

2.2.4 Interactions and coherence of AFOLU policies and ES

The conceptual focus of NAMAs and REDD+ on synergies among different actions indicates the importance of AFOLU mitigation mechanisms to reinforce each other. Synergies are only one quality for interactions between policy options. Policy interaction more generally has been defined as a "causal relationship between two policies in which one policy exerts influence on the other either intentionally or unintentionally" (Kalaba et al., 2014, p. 184). This occurs if one policy's decisions affect another policy's effectiveness (ibid).

Policies can be involved in various cases of interactions of which conflict and synergy are two opposite expressions (Kalaba et al., 2014). The distinct qualities of interactions are characterized very differently in literature. While Gehring & Oberthür (2009) refer to *synergistic* and *disruptive* interactions between institutions, Oikonomou and Jepma (2008) speak of *complementary* and *competitive* policy interactions. Makkonen et al. (2015) describe three different interaction qualities, which they call *mutual benefit, trade-off* and *mutual loss*. Building on this threefold distinction, the terms mutual benefit and mutual loss can be seen as synonyms for synergy and adverse effect, respectively. Following Kalaba et al. (2014), a definition for synergies is that one policy's goals and efforts are supported by those of another policy. A trade-off can be defined as one policy undermining or conflicting with another policy's effectiveness, and adverse effects as interactions that negatively affect the effectiveness of both policies.

However, interaction between policy components or decisions can be also both, conflicting and synergistic at the same time. Furthermore, an interaction can also incorporate multiple qualities simultaneously if it leads to contrary effects, for instance if the interaction of two implementation practices contributes to achieving one common policy objective while undermining another. The quality of an interaction can, for example, change in time or space, if it depends on learning processes or the local context. Certain policy interactions can, for instance, at first overwhelm and cause confusion for the involved actors which may, in the long term, improve institutional capacities and cooperation between actors. Co-benefits and trade-offs resulting from AFOLU mitigation measures depend on the region's development context, and the effects do not necessarily overlap in space or in time (Smith et al., 2014). Interactions on the level of affected ES depend on final implementation practices and the geographic context due to differences in topography and climate.

Specific interactions between policies determine their level of coherence, synergistic interactions implying high policy coherence. According to Nilsson et al. (2012), policy coherence "systematically reduces conflicts and promotes synergies between and within different policy areas" (p. 396). The effectiveness of policies can be significantly affected by their interactions, because coherent policies support the achievement of the policy objectives (ibid). Increased policy coherence through an optimal exploitation of synergies thus increases the effectiveness of the policies, while the presence of trade-offs and adverse effects can reduce it. Interactions between climate change (mitigation) and different policy and management choices are particularly strong in the AFOLU sector (Smith et al., 2014). The outcomes of AFOLU mitigations measures are known to go beyond the reduction of GHG emissions (Bustamante et al., 2014). In the words of Smith et al. (2014), "mitigation in the AFOLU sector is embedded in the complex interactions between socioeconomic and natural factors simultaneously affecting land systems" (p. 836). Understanding how policy options interact, whether in a synergistic or conflicting way, is important in order to assess their effectiveness (Kalaba et al., 2014). Efforts to analyse policies can thus benefit from an approach focused on their interactions. The lack of knowledge on policy interactions despite the significant role they play in the implementation and outcome of policies highlights the need to explicitly include such considerations at the science-policy interface.

Smith et al. (2014) specifically suggest that AFOLU mitigation options should be assessed regarding their potential impact on all ES provided by land. The ecosystem services approach has been proposed as an important tool to frame complex problems in social-ecological systems and challenges to their governance, such as emerging trade-offs (Makkonen et al., 2015), and it can equally be used to frame emerging synergies. Coherence analyses of AFOLU mitigation policies may consequently be improved by including the examination of interactions among affected ES (impact-level interactions). However, case studies following this approach, especially in a complex policy context, are still scarce or non-existent.

Scientific publications about the analysis of policy interactions have used the terms 'policy integration' (Nilsson & Persson, 2003; Jordan & Lenschow, 2010) and 'policy coherence' (Jones, 2002; Makkonen et al., 2015). A separation between the concepts has been offered by

Nilsson et al. (2012), describing policy integration analysis as a study of the policy (making) process including the institutional arrangements. Policy coherence analysis is situated further downstream and concerns the policy outputs, including objectives and instruments, and the implementation practices (see figure 4).

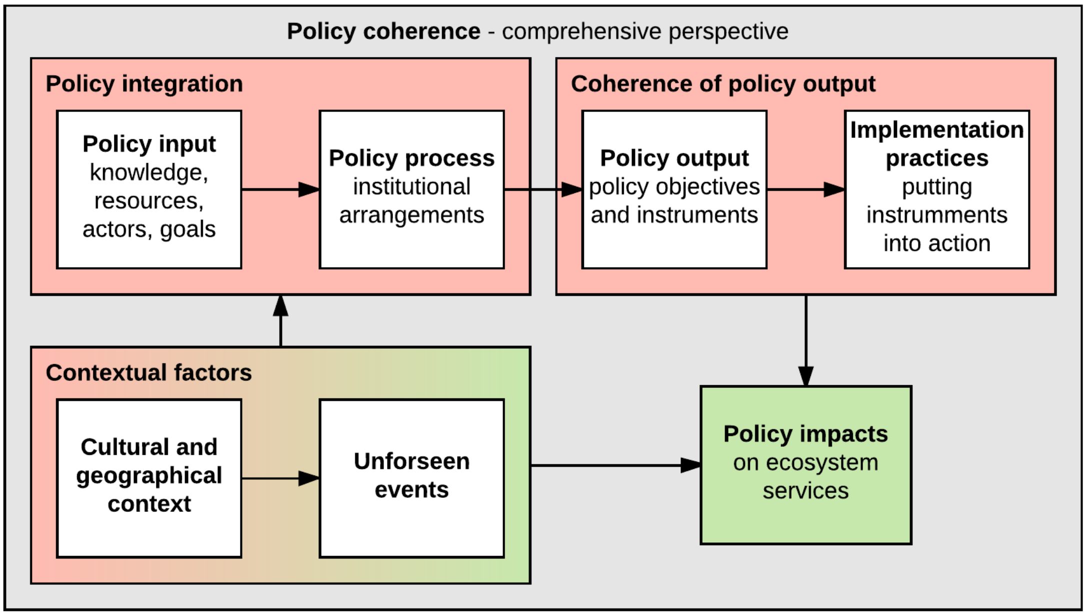

Figure 4: Policy coherence in an analytical framework (adapted from Nilsson et al., 2012).

The distinction between policy integration and coherence only serves heuristic purposes since process, outputs and outcome are closely linked. A high level of integration in the policy process is expected to similarly increase the level of coherence among the respective policies (Nilsson et al., 2012). Environmental policy integration in specific is claimed to aim at “achieving sustainable development and prevent environmental damage; removing contradictions between policies as well as within policies; and realising mutual benefits and the goal of making policies mutually supportive” (Collier, as cited in Nilsson & Persson, 2003, p. 334). Policy interactions as defined by Oikonomou & Jepma (2008) can take place along the entire chain from objectives, instruments, implementation to outcomes and the socioeconomic context. Merging the entire system depicted in figure 4 (policy integration, the coherence of policy outcomes and implementation, contextual factors, and policy outcomes in terms of ES impacts) into an integrated policy coherence approach allows to analyse interactions even more inclusively. Such a comprehensive coherence analysis offers many possibilities to identify synergies and trade-offs, but it “requires a strong multidisciplinary effort, from political and institutional analysis, through to knowledge and models about the link from policy design and instruments to the behaviour of economic sectors, […] individual actors in the ‘real world’” (Nilsson et al., 2012, p. 397) and impacts on ES. The analysis of ES impacts is challenging, since not only the policy process but also policy impacts are subject to changing preconditions, unforeseen events and, by extension of Nilsson et al. (2012), to the local geographical and cultural context.

Considering the wide range of impacts AFOLU policies may have on ES, emerging interactions among those impacts are equally diverse. A conceptual framework to examine interactions between ES, suggested by Bennett et al. (2009) highlights how processes (or policies) can interact indirectly (figure 5). Taking an inclusive perspective on policy interactions, the impacts of distinct policy instruments on ES pose an indirect policy interaction if the affected ES are linked. Assuming the two processes taking place within ecosystems depicted in figure 5 result from two different AFOLU policies, the policies interact indirectly by affecting ES B and ES C, which themselves directly interact. This interaction may alter the benefits that society derives from the affected services.

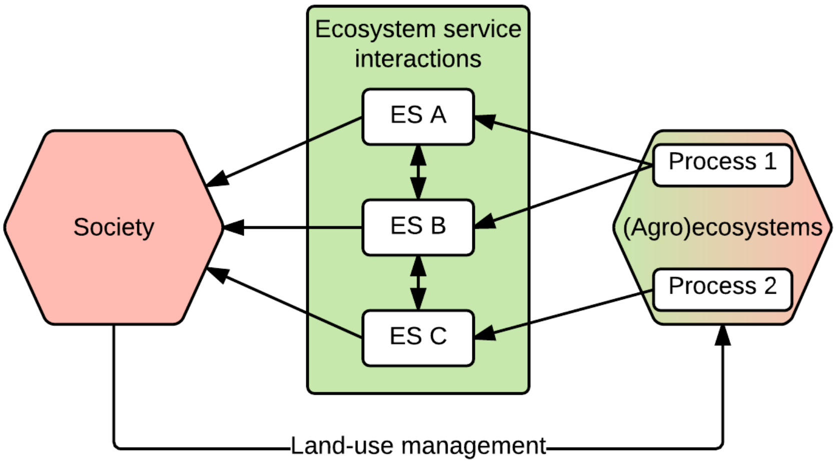

Figure 5: Indirect (policy) interactions resulting from interacting ES (Bennett et al., 2009).

All these insights to the complexity of the multi-policy governance of ecosystem services allow a comprehensive perspective on potential interactions between national AFOLU mitigation efforts. The presented review was indispensable for the development of a conceptual framework and research methodology to analyse interactions between AFOLU policies. In the following section, the findings presented in this chapter are synthesised in a framework to construct a comprehensive conceptualisation of AFOLU policy coherence.

2.3 Conceptual framework

In developing the conceptual framework visualised in figure 6, I followed assertion by Bennett et al. (2009) that relationships among ES can be better examined by an integrated social-ecological approach. Since institutional processes, diverse policy outputs and ES impacts are all at the centre of this research, it is highly interdisciplinary, relying on insights from both social science and ecology. Loosely based on Ostrom (2007), social-ecological approach can be composed of considerations of the resource system, i.e. natural ecosystems, and the governance system, i.e. actors using the resources and institutions that regulate this use.

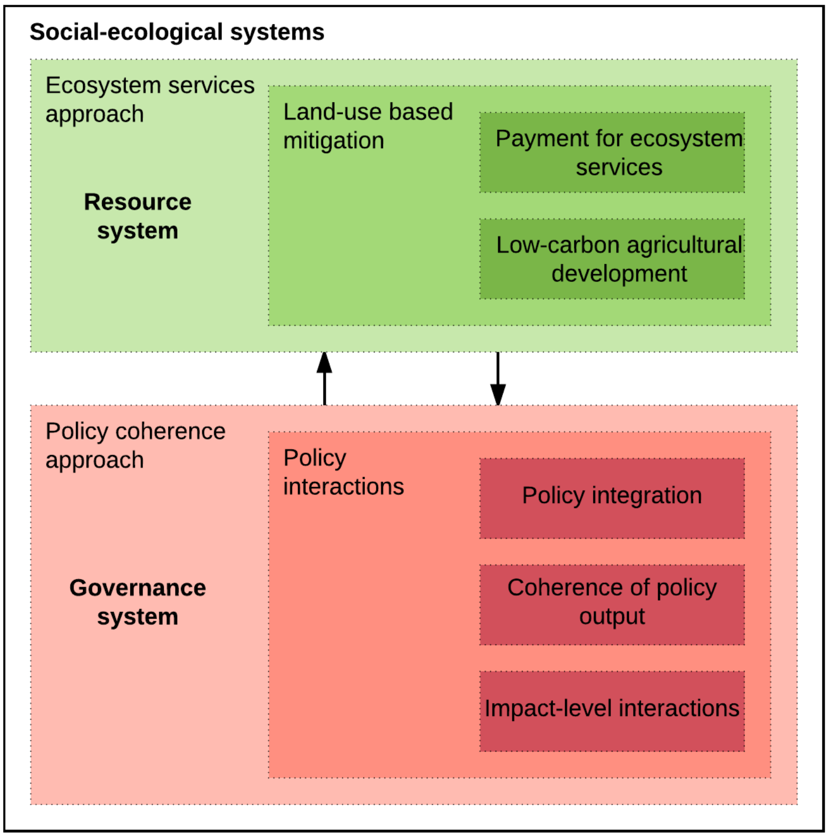

Figure 6: Conceptual framework for AFOLU policy coherence as part of a social-ecological system.

The policy coherence concept has been claimed to offer a suitable approach to analyse how multiple policies simultaneously affect different ES (Makkonen et al., 2015). It can been described as "the systematic promotion of mutually reinforcing policy action across government departments and agencies creating synergies towards achieving the defined objective" (Jones, 2002, p. 391). The definition of Jones (2002) only covers synergies because the author distinguishes between policy coherence, consistency and co-ordination. While consistency refers to avoiding conflict among policies, co-ordination describes inter-agency meetings or committees (ibid). In this analysis, I combine all three aspects described by Jones (2002) within a broader framing of policy coherence. The concept of policy coherence applied here thus includes all interactions affecting the achievement of policy objectives, including inter-agency processes, institutional arrangements as well as interactions of the outputs and outcomes.

While policy coherence traditionally focuses on the governance system, a special emphasis on the (natural) resource system needs to be established to examine the coherence of AFOLU policies. Therefore, I integrated and largely drew on the ecosystem services approach, including biodiversity[2]. Thereby I emulated the deeds of Makkonen et al. (2015), who conclude that a "major advantage of an approach focusing on ecosystem services is the drive to assess the impacts of policies simultaneously on several goods and benefits that ecosystems provide

[2] Biodiversity is generally seen as conceptually distinct from ES, nonetheless linked through diverse relationships and strong interactions (Schroth & McNeely, 2011; De Beenhouwer, Aerts, & Honnay, 2013; Ellison et al., 2017). For practical purposes, I followed Beer et al. (2003) and Power (2010) in considering biodiversity as an ES itself.

to humans" (p. 161), which gives a more holistic view on the policy coherence. The ecosystem service concept has already been applied in several policy contexts and initiatives around the world (Kosoy & Corbera, 2010). The authors of the IPCC's fifth assessment report suggest that recent frameworks for assessing ES "provide one mechanism for valuing the multiple synergies and trade-offs that may arise from mitigation actions" (Smith et al., 2014, p. 816).

In sum, key variables in a coherence analysis of AFOLU policies cover the policy (making) process, policy outputs and their outcomes in terms of ES impacts. These components of different policies are linked through different interaction qualities, i.e. synergies, trade-offs and adverse effects. Synergies include all cases of policy interaction where components of multiple policies support the same objective or expected outcome. Trade-offs are defined as cases of interaction where the objectives or outcomes of one policy are undermined by another policy. Lastly, adverse effects include the interactions that reduce the effectiveness of both interacting policies simultaneously. In the policy process, interactions result from mechanisms of institutional and interinstitutional coordination or the policy framework. Interactions of policy outputs are caused by policies relying on the same policy options or by including options that affect the same processes. Interactions of ES impacts are mostly results of increasing forest cover, which may have diverse impacts on various services. Depending on the (mix of) tree species and density, for instance, there can be a trade-off or a synergy between the rate of carbon sequestered and the level of biodiversity supported.

3. Methodology and material

The identification and examination of potential AFOLU policy interactions was conducted through a complemented methodology for a policy coherence analysis. For this purpose, the methods proposed by Nilsson et al. (2012) have been adapted. Their original analysis emanates from an environmental policy reference framework and primarily investigates the interactions between sectoral and environmental policies. The authors' scheme for analysing policy coherence based on interactions among three policy layers has been extended by two more layers focused on the policy process and the impact level. The resulting scheme allows the analysis of interacting processes, objectives, instruments, implementation practices and ES impacts (see figure 7).

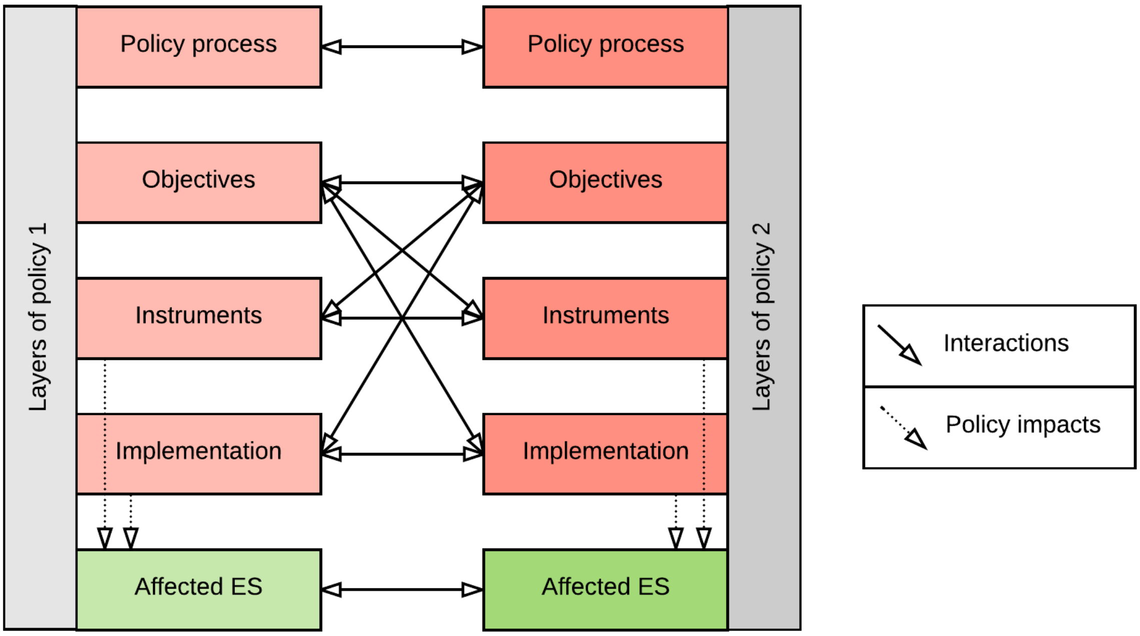

Figure 7: Interactions between different layers of individual policies ('layered' approach to policy coherence, adopted by Nilsson et al., 2012).

To help the identification of ES interactions, a distinction can be made between (a) separate policies that affect the same ES and (b) separate policies that affect distinct but interacting ES. The latter can further be differentiated, following Bennett et al. (2009), between types (b1) naturally interacting ES and (b2) ES that are affected by a common driver (see figure 7). These drivers include the behaviours of various actors, such as farmers or consumers, which are influenced by the analysed policy instruments. Drivers of ES change considered in this coherence analysis are thus mediated by policy instruments.

Interaction type (a) is depicted in figure 8 as the interactions between policy 1 and 2, since the drivers they affect have an impact on the same ES A. Type (b1) is found between policy 1 and 3 as they only interact through the (unilaterally) linked ES A and B. Type (b2) can be seen between ES B and C as they are connected through the common driver III. This is not only an interaction of ES but also of policies since policy 2 and 3 both affect the common driver. Policy interactions can, of course, also take place on multiple levels simultaneously. An example can be identified between policy 1 and 2, since their affected drivers I and II both have an impact on the same ES A while policy 2 (through driver III) also has an impact on ES B, which interacts with ES A.

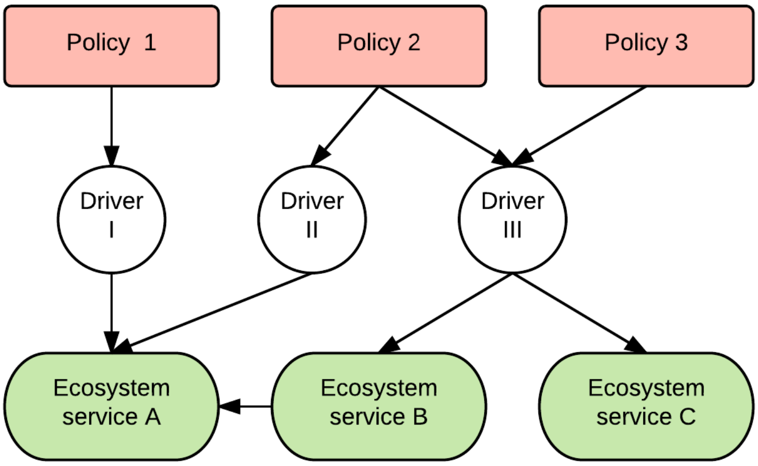

Figure 8: Interactions among policy impacts on ecosystem services, mediated by drivers.

Similar to the framework by Nilsson et al. (2012), the developed methodology for a coherence analysis included several steps. First, an inventory of all relevant policy layers is required. This is used, in the second step, to contrast these layers between policies, from which a tentative list of potential interactions is deduced. In the last step, experts covering the relevant social-ecological and policy sectors were interviewed to verify these findings and gain an in-depth understanding of the potential interactions. In contrast to Nilsson et al. (2012), who analysed the strength of policy interactions, I focused on the quality of the interactions. If applicable, evidence from literature was added to strengthen the validity of an identified interaction, which also goes beyond the original coherence analysis framework my methods emanate from. The individual steps are described in more detail after a brief operationalisation of key variables for analysis.

3.1 Steps of the developed methodology

3.1.1 Operationalisation of the framework

In the developed methodology, interactions among policy components from five layers are included, as figure 7 showed. Those layers cover the policy process, policy outcomes including objectives, instruments and implementation practices and affected ecosystem services. There are different mechanisms that cause interactions among components. Those include the role of the broader policy framework in the policy making process, which can have a prioritising or guiding character. Mechanisms also vary depending on the layers involved in interactions. For one, multiple policy components of the same layer can interact. This can occur if different policies rely on similar components (e.g. the same instrument) or if different components pursue the same or contradictory purposes. Interactions can also occur between components of different policy layers of policy outputs. This is the case if an instrument or implementation practice of one policy helps achieve the objective of another. Due to the inherent uncertainty in discussing future policy outcomes, most identified interactions are referred to as *potential*.

Following Makkonen et al. (2015), I will make a distinction between three types to describe the quality of a potential interaction: synergy, trade-off, and adverse effect. The authors' original terms were different but synonymous and have been changed to adhere to the common terminology found in the literature on AFOLU mitigation. The operationalisation of synergies used here is broad, including all interactions between components of multiple policies that describe of may have a beneficial impact on the effectiveness of one or more policies. Trade-offs are operationalised as interactions between components of multiple policies where an increase of one beneficial impact may decrease another beneficial impact. As adverse effects all those interactions between components of multiple policies are described that may have a detrimental impact on the effectiveness of both policies.

Interactions among affected ES take a special role, since their interactions are even more complex than direct policy interactions and associated with larger knowledge gaps and higher uncertainty. The relationships among ES are broken down to individual interactions based on the unidirectional influence of one ES over another. Furthermore, there are generally no adverse effects among their impacts since components of AFOLU policies aim to enhance at least one ES. On the impact level, interactions are thus examined with regard to the correlation of affected ES, where positive correlation causes a synergy and negative correlation a trade-off.

The selection of affected ES that I considered in the coherence analysis was based on references in the policy documents. The considered documents used different terms but all referred to impacts on ecosystems in their objectives and co-benefits. In many cases, it was clear which ES are targeted with specific statements, in other cases it was very implicit and had to be operationalised for ES using literature that bridges the gap between different terminologies by explaining ecosystem functions. The results chapter includes a detailed explanation of the operationalisation process under 4.7 “ES interactions in policy objectives”, which includes an overview of the policy references and their corresponding ES in table 5. The final selection is comprised of the following ES:

- Carbon sequestration (climate regulation or mitigation through biomass production)
- Water regulation
- Water purification (correlates with water quality)
- Pest control
- Erosion control
- Freshwater provision
- Food production
- Biodiversity

3.1.2 Content and coherence analysis

To gather information on the policy context, in addition to the content analysis of policy documents for the land-use NAMAs and REDD+ in Costa Rica, the policy framework was considered by examining loosely related documents for relevant contents. Following a method by Kalaba et al. (2014), various national reports, strategies and development plans that link to issues of land-use, conservation or climate were reviewed to gain insights into the legal framework and policy context. This helped understand the national development pathways and how they might affect interactions of the analysed policies. Consulted policy documents encompass the Intended Nationally Determined Contribution, National Development Plan (Plan Nacional de Desarrollo, PND), Forestry Development Plan (Plan Nacional de Desarrollo Forestal) and the Climate Change Action Plan (Plan de Acción de la Estrategia Nacional de Cambio Climatico). In reviewing these strategic policy documents, I searched for references that relate to the broader objectives and mechanisms of the ENREDD+ and land-use NAMAs. Taking the strategic framework into account helped put the three mitigation policies into perspective and enabled inferences as to how the national policy framework might support their effectiveness or affect their interactions by prioritising components of the NAMAs or ENREDD+.

After examining the broader policy context, the content analysis of documents for the NAMAs and REDD+ was prepared. First, key documents of the mitigation policies at hand were identified through an Internet search in March 2017 and conversations with informants at UNEP-WCMC. The selection included Costa Rica's National REDD+ Strategy (ENREDD+), the REDD+ Implementation Plan (PI-ENREDD+, state March 2017), the Low Carbon Livestock Development Strategy and several concept notes and reports for the Livestock and Coffee NAMAs. Table 2 shows a list of the analysed policy documents and the abbreviations used to refer to them in chapter 4 "Results". The Livestock NAMA is the cornerstone of the Low Carbon Livestock Strategy (Estrategia de Ganadería Baja en Carbono, EGBC) (Chacón et al., 2015). For this reason, the EGBC was directly included as a policy document of the Livestock NAMA.

Table 2: Analysed policy documents and their abbreviations used in chapter 4.

Policy document	Reference in text	Year
Estrategia Nacional de REDD+ Costa Rica (National REDD+ Strategy)	ENREDD+	2015
Plan de implementación de la Estrategia Nacional REDD+ Costa Rica (REDD+ Implementation Plan)	PI-ENREDD+	2017
Ganadería Baja en Carbono en Costa Rica: Informe Final - Estrategia y Plan de Acción (Low Emission Livestock Strategy)	EGBC	2015
NAMA Ganadería Costa Rica (Livestock NAMA Costa Rica)	NGCR	2015
Livestock NAMA Concept	LNC	2014
Concepto NAMA Fincas Ganaderas (Livestock Farms NAMA Concept)	CNFG	2013
Coffee NAMA – tools for a low-carbon development (NAMA Café de Costa Rica – Una herramienta para el desarrollo bajo en emisiones)	(Nieters et al., 2010)	2016
NAMA Café Costa Rica – MRV System of the Carbon Footprint in Green Coffee Production and Processing	(Rojas et al., 2016)	2015

Following Nilsson et al. (2012), the content analysis of those documents began with a descriptive inventory of the policies to compile all potentially interacting policy components. This inventory was facilitated by categorising identified components into the four policy layers, i.e. relevant content of the documents was itemised and categorised as either policy objective, instrument, implementation practice or ES impact. Similar to policy coherence research by Kalaba et al. (2014), the content analysis was broadly based on the inductive grounded theory approach, grouping contents into themes that emerged from the analysis. Clusters of components within emerging themes helped to identify interactions and structure the presentation of results in chapter 4. The layer of ES impacts took up a special role in the content analysis, as information on those policy impacts was mostly implicit in the documents. By estimating the ES impacts of the policy outputs based on findings from literature (and later also from interviews), they were made explicit to allow including them in the coherence analysis.

In the next step, proceeding to the policy coherence analysis, screening matrices were created for each emerging theme. Each matrix contained the identified objectives, instruments, implementation practices and if applicable, affected ES of all three policies for one theme. Components of the NAMAs are listed on one axis and those of the National REDD+ Strategy and Implementation Plan on the other. Taking into consideration general findings about (AFOLU) policy interactions from literature, all components of one axis were checked for possible interactions with components of the other in a combinatorial test. More specifically, it was expedient to search for overlaps and differences within each theme, as shown in the analysis by Kalaba et al. (2014). Examining how policy objectives, instruments, implementation practices and ES impacts of one axis affect these components of the other axis, and vice versa, led to the determination of broadly defined policy interactions. As a result, an extensive list of all interactions identified to be theoretically possible, independent of their probability, was set up and organised by the original themes of the matched components. Complex interactions within themes need to be disaggregated into single policy decisions and recombined in an iterative process. These interacting clusters of policy decisions and different components are then tentatively assessed regarding their quality, from clear synergies, trade-offs and adverse effects to more contingent interaction qualities that combine multiple effects.

3.1.3 Interviews

Since the analysis of abstract policy documents is not sufficient to achieve the practice-oriented research objective, various expert interviews were conducted before and after the coherence analysis. One purpose was to gain insights into the policy processes and how they may interact, leading beyond indications found in the analysed documents. Furthermore, the informants helped in attaining more specific information on the policy outputs and realistic expectations regarding (ES) impacts. In the framework proposed by Nilsson et al. (2012), "a combined panel of scientists and expert policy officers is recommended" (p. 401) for a coherence analysis. For reasons of feasibility, instead of a panel workshop where the invited experts would have been able to exchange opinions, individual interviews were conducted in two rounds. Initially, several experts on the regional context and on REDD+ were interviewed at UNEP-WCMC based on their experience and involvement relevant to the present research. This yielded an improved general understanding of the mitigation mechanisms and their co-benefits as well as information on the regional context and various contacts of experts in Costa Rica, including researchers at the Tropical Agricultural Research and Higher Education Center (CATIE) and officials. Based on the snowball principle, those national experts provided additional contacts which provided a broad set of experts. The selection of informants was non-probabilistic and purposive, at least one official and one researcher directly involved in each policy was chosen and interviewed. Additional interviews were conducted with farmers and technical experts for specific aspects of this research, such as agricultural extension, carbon accounting and ES interactions. Table 3 gives an overview for the number and distribution of people interviewed orally. Depending on their expertise, informants where asked about possible policy interactions in this field, first very broadly and incrementally more concretely regarding the components identified in the policy documents. Ultimately, informants were asked to verify the exact interactions that had been compiled through the coherence analysis and relate to their field of expertise. Thereby, many interactions that had been considered to be theoretically possible were omitted for being unlikely. Those that were confirmed to be likely or to occur by informants were kept for further examination using literature and additional interviews.

Table 3: List of consulted experts and number of interviews conducted.

Group of informants	Number of experts	Number of interviews
UNEP-WCMC staff	8	8
Officials and consultants	9	12
CATIE Researchers	7	10
Farmers and coffee processers	6	6
Total numbers	**30**	**36**

Six key experts were approached based loosely on the Delphi method as explained by Verschuren & Doorewaard (2010), where after a first round of interviews the informants receive a summary of the gathered information in order to allow adjustments to their answers in a second round. This method allows to integrate the knowledge of different experts and get closer to a consensus without the need to bring them together in a workshop. In the first round, semi-structured interviews with open questions were conducted via Skype to gather different kinds of knowledge and considerations. The answers were examined closely to indicate broad outlines and differences. In a second round of interviews, conducted face-to-face in Costa Rica, gained insights and particularly contradictions were shared with the informants, giving them the opportunity to reconsider their initial answers and adapt them. During these structured interviews, more concrete questions were asked to verify findings from the literature review, content analysis and previous interviews. Lastly, the answers were examined again and checked for variations from findings of the first round. Insights gained from the interviews improved the knowledge on the policies, for instance through more detailed information on institutional arrangements, implementation practices and ES impacts, and allowed the verification of policy interactions identified through the coherence analysis.

3.2 Concluding remarks on the analytical framework

The framework described above, which has been developed as part of this research to fill a gap in literature, constitutes the answer of sub-question 1. Due to the integration of sound methodologies from renowned scholars with different disciplinary backgrounds, this framework can be a useful tool for policy analysis in the face of the environmental and climate crisis as our currently defining policy task. It was applied in the policy coherence analysis of the two land-use NAMAs and national REDD+ efforts in Costa Rica, which can be regarded as a test for the usefulness of this framework. The results of this analysis are presented in the following chapter, beginning with interactions in the policy process and outputs, closing with potential impact-level ES interactions.

4. Results

In the case of REDD+ and the land-use NAMAs in Costa Rica, the quality of many identified policy interactions for both institutional arrangements and ecosystem impacts is highly dependent on the local context and the timeframe. Often the implementation process needs to be more advanced to be able to determine the net quality of an interaction. In the following chapter, interactions are therefore not organised by their quality but by theme to contrast the synergistic and conflicting side of each case of policy interaction. Another advantage of this array is the better usability of results by actors interested in specific interaction themes related to their involvement in the policy.

Due to the large amount and diversity of potential interactions identified, table 4 gives an overview of most synergies, trade-offs and adverse effects between the policies (red) and their ES impacts (green). Furthermore, the chapter concludes with a summary of the interactions.

Table 4: Overview of interactions. "+" used for synergies, "↕" for trade-offs, "-" for adverse effects.

Theme	Coffee / Livestock NAMA	Interaction quality	(PI-)ENREDD+
Productivity and profitability	Increase land-use competitiveness of livestock farms	↕/+	Increase land-use competitiveness of forest
	Spare land used for trees	+	Re/afforestation
	Spare land used to increase production	↕	
	Preventing farm abandonment	↕	
Restoration of degraded land	Re/afforestation on degraded pastures	+	Re/afforestation on degraded land
Low-carbon marketing	Marketing of low-carbon coffee & dairy products	+	Affordable low-carbon certification schemes
Support of rural population	Special attention to increase income of small-scale farmers	+	Promote participation of small-scale farmers
Forest conservation	Promote export and domestic demand of livestock products	↕	Attend drivers of deforestation
	Forest plantations on farms, live fences, forage banks	+	
Agroforestry systems (& SPS)	Promote trees on farms	+	New financial modalities and support for AFS & SPS
Payment for ecosystem services scheme	PPSA payments for live-fences and diverse tree species on coffee plantations	+	Increase investments in PPSA, widen coverage
Complication of MRV integration	NAMA-specific requirements, less advanced process	-	Higher REDD+ standards, more advanced process
Carbon accounting	Carbon credits for increased sequestration on farms	-	Carbon credits for increased sequestration on farms
	Distinct reference emission levels (yet to be) established	-	Reference emission level through IPCC methods
	Central responsibility for national GHG inventory	+	Central responsibility for national GHG inventory
Inclusiveness	Stimulating the participation of the family and youth on farms	+	Gender mainstreaming and participation of the youth
Communication strategies	Increase environmental awareness of consumers,	+	Inform civil society about importance of forests

Reconciling stakeholder interests	Dissemination of integrated information, awareness raining, Livestock Roundtable	+	Strong focus of PES scheme on productive systems, move beyond restrictions
Capacity needs & capacity building	Diffusion of integrated information by strengthened producer associations	+	Joint training and extension by agricultural and environmental sectors
	Capacity building of trainers at MAG	+	Train officials from MAG and MINAE, strengthen their assistance and support for producers
	Dependence on consultants	-	Dependence on consultants
Support from academia	research on low-carbon livestock farming, participation of universities	+	Strengthen the participation of academic and research organisations
Inter-institutional coordination & cooperation	Establish permanent exchange between MAG, FONAFIFO and sectoral organisations; harmonise interinstitutional coordination	+	Identification of mechanisms & actions for the collaboration of public entities to achieve complementary goals
	(Too) many actors involved	-	(Too) many actors involved
Diverse funding streams	NAMA Facility funds, private investments, etc.	+	Forest Carbon Partnership Facility, potential others
Water services (freshwater & water regulation)	Reduced by young forest plantations	↕	Enhanced by many policy instruments
	Enhanced by dispersed trees on farms	+	
		↕	Reduced by young forest plantations
Biodiversity	Enhanced by increased tree cover (& diversity) on farms; enhanced by reduced fertilizer use on coffee plantations & herbicide use on pastures	+	Enhanced by maintained and increased tree cover; enhanced by reduced pesticide use on nearby farms through barrier effect of forests
	Limited by the need for economical sales volumes of non-timber forest products	↕	
	Enhanced by filling gaps in landscape connectivity on farms with AFS/SPS	+	Enhanced by filling gaps in landscape connectivity on forest conservation areas
Pest control	Enhanced by enhanced biodiversity; enhanced by barrier effect of windbreaks; enhanced by introducing non-host vegetation on farms	+	Enhanced by enhanced biodiversity; enhanced by barrier effect of forests
	Reduced under specific circumstances by providing habitat for some pests with certain shade trees for coffee	↕	

Water purification	Enhanced by reduced fertilizer and pesticide use	+	Maintained by conserved forests; enhanced by re/afforestation
	Reduced by fighting invasive plants for carbon sequestration with herbicides	↕	
Carbon sequestration	Enhanced by increased permanence of C-stocks from enhanced fire & pest control and from less fires started on pastures; enhanced by efficient biomass production from enhanced biodiversity; enhanced carbon stocks by soil conservation through AFS/SPS and rotational grazing	+	Enhanced by increased permanence of C-stocks from enhanced fire & pest control; enhanced by efficient biomass production from enhanced biodiversity; enhanced carbon stocks by soil conservation through forests
	Reduced by improved pastures that compete for water with young trees for carbon sequestration; limited by low carbon content of *Erythrina poeppigiana*	↕	
Pollination	Increases coffee production; enhanced by AFS and forest patches on livestock farms	+	Enhanced on farms by nearby forest patches

As mentioned in subchapter 3.1.2, identified components were organised in and interactions derived from clusters that reflect the emerging themes from the content analyses. The interactions presented below are structured analogously within the same themes.

4.1 Economic interactions

4.1.1 Profitability of land-use types

Both NAMAs inherently contain a strong focus on development, they aim to increase the (eco-)competitiveness of coffee and livestock farms (Nieters et al., 2010; LNC). Since agriculture and forestry as two different land-use types inevitably compete for land, the NAMAs objective conflicts with the objective of the ENREDD+ to increase the competitiveness of forests. Higher profitability of farms will increase the competitiveness of the agricultural land use and thereby decreases the relative competitiveness of other land-use types, including forestry. This potential trade-off may be offset by the objective and corresponding instruments of the ENREDD+ to improve the competitiveness of the financial mechanisms for both forests and agroforestry ecosystems in relation to other types of land-use through modifications to the PPSA. Improving the financial mechanisms of forestry systems, AFS and SPS has important implications for the competitiveness of land uses promoted by the NAMAs and the ENREDD+. To convince more producers to adopt AFOLU measures, the financial incentives offered to them must fully cover opportunity costs, i.e. must be competitive with the profitability of other land uses (Smith et al., 2014). Given that the NAMAs aim to increase the farms' competitiveness and the ENREDD+ includes forests and AFS/SPS, the resulting interaction quality for farms with a dominant agroforestry component can even be a potential synergy.

As an objective (EGBC) or important co-benefit (NGCR), the Livestock NAMA aims to increase the sector's productivity (produce per animal or area of land). If production (amount of animals) is not increased to the same extent, which according to official 3 is considered unlikely due to the high investments necessary, the required production area will decrease. This creates additional space (farmer 1) for potential re/afforestation. Considering that the ENREDD+ aims to promote forests in productive systems, there is indication for a potential synergy between this objective and the possible implementation practice of the Livestock NAMA to plant trees on spare land. Between 2000 and 2014, the number of animals in Costa Rica declined from 1,369,705 to 1,278,817 (-7.11%), pastures decreased from 1,304,883 to 1,044,385 hectares (-20%). At the same time, the production of milk has increased from 722 million to 1,077 million metric tons. This "is evidence that a sustainable intensification of livestock farming is possible" (MAG, CORFOGA, CATIE, & UNEP, 2015, p. 22) and can create spare land for forestry use.

In principle, however, increasing yields may also fail to spare land as a result of rebound effects (Smith et al., 2014). If income increases and financial instruments to simulate investment achieve their goal, famers may be able to eventually expand production. This is supported by Angelsen (2010), who found that locally increasing yields tend to stimulate agricultural expansion. Increased productivity consequently also creates a potential trade-off with forest conservation objectives of the ENREDD+, discussed in more detail in subchapter 4.2.

In the past, much of Costa Rica's natural reforestation occurred on abandoned farms (researcher 1; official 2; official 4). In fact, 65 percent of reforestation takes place on former pastures (ENREDD+). However, the co-benefit of increasing sectoral profitability (NGCR) aims at avoiding the abandonment of farms. The maintained use of pastures as favoured by Livestock NAMA at least hampers the establishment of full secondary forests by limiting reforestation to forest patches and SPS. This conflicts with the ENREDD+ objective to promote reforestation on degraded land. Consequently, the described interaction constitutes a potential trade-off between reforestation plans of the ENREDD+ and the agricultural land use promoted by the Livestock NAMA.

4.1.2 Restoration of degraded land

According to the PND, the uncontrolled development of the livestock sector has been mentioned by many studies as a reason for soil degradation (MIDEPLAN, 2014). As a consequence, livestock farms entail large parts of degraded land, the proportion of degraded pastures in Costa Rica lies between 10 (official 3) and 40 (researcher 1) percent. Reforestation on degraded pastures clearly represents a potential synergy between the Livestock NAMA and the ENREDD+. Decreases in the livestock carrying capacity is given as an indirect driver of deforestation in the ENREDD+. Landscape restoration by planting forest patches on cattle farms contributes to both the reforestation objective of ENREDD+ and to the Livestock NAMA's objective (EGBC) and co-benefit (NGCR) to increase profitability of farms through the benefits trees can provide. The Livestock NAMA states that "REDD+ and Livestock NAMA work in a coordinated way to restore degraded areas in selected farms with the many co-benefits it entails" (LNC) (MAG et al., 2015, p. 4). An implementation example for landscape restoration through the Livestock NAMA is the REDD+ Landscape CCAD-GIZ Programme in the Central Pacific Conservation Area[3]. Obviously, this synergy may also increase both policies' effectiveness towards climate mitigation through carbon sequestration. This increase results from most synergy effects and will henceforth not always be explicitly mentioned.

4.1.3 Marketing of low-carbon, quality products

The objective of the Coffee NAMA to create access for producers to new markets (Nieters et al., 2010) may be achieved through the stated instruments of carbon audits and the marketing of low-carbon coffee. Promoting affordable low-carbon certification schemes, as an instrument of the PI-ENREDD+, may contribute to this objective. Similarly, the marketing of quality meat and low-carbon dairy products may be facilitated by the Livestock NAMA (NGCR, official 2). Collaborating with the environmental sector in this regard is expected by official 3 to improve the livestock sector's image and thereby maintain or increase domestic demand. Embracing private governance mechanisms such as certification in pubic polices can increase the effectiveness of both approaches. Public regulations generally provide enabling conditions for private and hybrid governance instruments, where various instruments ideally complement rather than undermine each other (Lambin et al., 2014). Coherent efforts towards the marketing of (certified) low-carbon, quality products thus presents another potential synergy between REDD+ and both NAMAs.

4.1.4 Support of rural population

The NAMAs' co-benefits to increase profitability and consequently the income of the farmers, especially of small-scale farmers, demonstrates potential for synergistic interaction with components of the ENREDD+. An example is the objective to maintain and improve the way of life for the rural population in areas with valuable ecosystems. Similarly, a synergy may occur with the objective to "promote the participation of small-scale farmers and agroforestry producers in REDD+" within special management regimes (ENREDD+) (MINAE, 2015, p. 38).

4.2 Interactions regarding forest conservation

Involving farmers in climate change mitigation, as intended by the NAMAs, may affect their compliance with forest conservation laws. According to Smith et al. (2014), mitigation measures in the AFOLU sector can also have a positive effect on the enforcement of conservation policies. Efforts of the ENREDD+, including the prioritisation of biodiversity conservation areas and additional control of illegal deforestation, may thus be supported by a synergistic interaction with agricultural mitigation efforts of the NAMAs.

A direct trade-off may be seen between the Livestock NAMA's objective to strengthen the sector by promoting exports and domestic demand of livestock products (LNC) on the one hand and the objective of the ENREDD+ to attend drivers of deforestation on the other. The ENREDD+ even specifically states plans to align public policies and incentives that generate deforestation. Increasing the demand for livestock products may in fact incentivise deforestation, given that the ENREDD+ mentions livestock farming as a driver of deforestation in three deforestation zones, i.e. Abangares, Cordillera Volcánica Central and Cordillera Sur.

[3] The CCAD-GIZ Programme integrates the Livestock NAMA in REDD+ activities for soil and water conservation in an area with high levels of degradation, see http://reddlandscape.org/costa-rica/?lang=en

As much as 70 percent of deforested land in Costa Rica is eventually turned into pastures (ENREDD+).

Approaching the causes of forest degradation is another stated objective in the ENREDD+. Despite being only minor factors in Costa Rica, illegal extraction of trees to produce fence posts for pastures and cows foraging in forests during dry season both contribute to forest degradation (researcher 1). There are instruments promoted by the Livestock NAMA (NGCR) that mitigate those drivers, illegal felling may be reduced through forest plantations on farms and cows may be prevented from foraging in forests through live fences and on-farm fodder production. This is supported by (Minang et al., 2011), who found that the on-farm production of timber through agroforestry can reduce emissions from forest degradation by alleviating pressure on forests. A potential synergy is thus identified between the described ENREDD+ objective and NAMA instruments.

4.3 Interactions through agroforestry and silvopasture systems

An essential instrument of both NAMAs is the increase of tree cover on farms for carbon sequestration and multiple co-benefits. The Livestock NAMA promotes forest plantations and SPS with forest patches, live fences, dispersed trees and woody forage legumes (NGCR), while the Coffee NAMA promotes AFS with shade trees on plantations (Nieters et al., 2010). According to Feoli (2013), three-fourths of the Coffee NAMA's mitigation potential is based on carbon sequestration. Even higher potential results from biomass production in the livestock sector, since 70 percent of all the carbon sequestration in Costa Rica is taking place on livestock farms (EGBC). The ENREDD+ pursues the same objective to enhance forest biomass on agricultural farms through AFS and SPS. The document specifies as an instrument the planning of mechanisms for integrated agroforestry farms that combine ES with social and environmental benefits. The PI-ENREDD+ refers to planning new financial modalities for AFS and SPS as well as strengthening the Programme for Plantations that Leverage Forest, which finances tree planting activities for AFS and SPS producers using the trees as credit guarantee. Furthermore, the PI-ENREDD+ includes the revision of regulations for the forest exploitation in meadows. These regulation have been mentioned as an impediment to re/afforestation on farms because strict norms make the anticipated legal felling of the trees inconvenient or impossible and thereby the planting of trees less attractive (official 1; consultant 1; researcher 1). The ENREDD+ refers to developing a plan, in conjunction with the Ministry of Agriculture (Ministerio de Agricultura y Ganadería, MAG), to advise and support small holders in the introduction and improvement of farming systems with a forestry component, thereby integrating key instruments of the Coffee and Livestock NAMAs. Agroforestry-related objectives and instruments of the analysed policies mentioned above are clearly aligned. Mutually reinforcing efforts towards AFS/SPS demonstrate a potential synergy between the NAMAs and the (PI-)REDD+. Beyond the enhancement of various ES through AFS and SPS, the timber products and non-timber forest products obtained with tree-based agriculture diversify the producers' income (Smith et al., 2014).

4.4 Payment for ecosystem services

Jointly promoting AFS and SPS supports and is supported by another, closely related potential synergy. Costs or opportunity costs of increasing and maintaining forest cover may be compensated to some extent by the national PPSA, on which all three policies rely as an instrument. Investments in the existing PPSA are to be increased, as outlined in the ENREDD+. Furthermore, in the PI-ENREDD+, the widening of the PPSA coverage as well as new modalities and revised amounts are included. The CNFG directly refers to promoting the maintenance of REDD areas on pastures with Livestock NAMA activities. Official 2 expects payments from the PPSA for live fences on livestock farms to be implemented soon. Similarly, the PPSA is expected to contribute to the Coffee NAMA, which embraces the already existing payments to coffee producers with at least 70 trees per hectare (Nieters et al., 2010) as well as new payment modalities (researcher 3). The PPSA as a common financial instrument of all examined policies can lead to synergistic interactions in the development and application of the scheme and consequently increase the policies effectiveness. While this may create competition between interested farmers if PPSA funding is scarce (potential trade-off), its widening through REDD+ funds can favour the synergistic quality of the interaction.

According to Pagiola (2008), the relatively low and mostly untargeted PPSA payments in Costa Rica are likely to cause inefficiencies and payment for practices that would have been adopted anyway. Revising amounts and developing new payment modalities as part of all policies may resolve this problem.

Another potential synergy can be identified for the intentions stated in the ENREDD+ to prioritise the PPSA on protected forest areas. Approximately 50 percent of these areas are private and are therefore eligible for agroforestry or silvopasture systems (official 6), creating potential for policy instruments to reinforce each other in half of the protected forest areas. However, a potential trade-off may result from the remaining, public half of this area where productive systems are not allowed.

4.5 Interactions regarding emission monitoring and prioritisation of zones

4.5.1 Complication and confusion

Both the NAMAs (LNC; Nieters et al., 2010) and the ENREDD+ rely on an MRV system to account for emission reductions. A national System for the Monitoring of Land Cover, Land Use and Ecosystems (Sistema de Monitoreo de Cobertura y Uso de la Tierra y Ecosistemas, SIMOCUTE) is currently under development. SIMOCUTE, as part of the national monitoring, reporting and verification system, is hoped (consultant 2) and expected (official 3; consultant 1) to integrate specific monitoring requirements for the NAMAs and REDD+ activities. The integration is challenging due to different conditions for each policy and different standards of the donors (Michaelowa, Wemaere, Honegger, Hoch, & Matsuo, 2015; consultant 2). Progress in the development of SIMOCUTE has been described by consultant 2 as “painfully slow” and the sharing and use of data between the involved institutions as “not working”. Moreover, a lack of data as well as low accuracy and reliability of the national metrics have been reported as an obstacle to MRV in Costa Rica, particularly regarding emission reductions in the agriculture and forestry sector (Ryan, 2017). Costenbader et al. (2013) note that the integration of MRV for NAMAs and REDD+ in general requires high in-country capacities and can cause excessive confusion. They identify a tension “between the distinct character of the two work programs and the need to combine their efforts in order to avoid duplication and confusion in MRV and registration of emissions reductions” (ibid, p. 25). In addition to an integrated monitoring system, separate MRV systems for each NAMA may be required to calibrate the distribution of benefits[4] (DCC-MINAE, 2017). Harmonization of reference emission levels (REL, explained in more detail in the following subchapter) can lead to further complications, while a lack of harmonisation could cause disparities in accounting and problems in establishing the national accounting framework for REDD+ (Costenbader et al., 2013). Those issues indicate that the integration of emission monitoring may be overwhelming Costa Rica's institutional capacities at the expense of both policies. Thus, interactions in the policies' development and implementation of an MRV system cause a potential adverse effect.

4.5.2 Inaccurate emission accounting

REDD+ and NAMAs as implementation tools to attain mitigation pledges can generate internationally recognized carbon credits for verified emission reductions. If emission reductions occur where two mitigation mechanisms spatially overlap, carbon credits can be issued twice for the same reduction (Schneider, Kollmuss, & Lazarus, 2014). In this context, double counting is one of the mayor risks emerging from the simultaneous implementation of land-use NAMAs and REDD+ activities in Costa Rica (consultant 1; consultant 2; official 1; official 3; researcher 4; researcher 5). Emission reductions could be credited twice, through both REDD+ and the respective NAMA, for forest areas on farms, (avoided) deforestation on farms, natural regeneration and plantations on farms, trees on coffee plantations and live fences and trees on pastures (DCC-MINAE, 2017). Proper integration of the policies with closely aligned MRV methodologies and spatially explicit national registries may reduce the risk of double counting (Costenbader et al., 2013). A national MRV system and a common registry are currently under development (official 1; official 3; consultant 1). However, whether this system will be able to integrate monitoring requirements of both mitigation mechanisms remains unclear (consultant 2).

Actual emissions determined through the MRV system will be compared against a REL, giving an emission pathway in a business-as-usual scenario, to quantify reductions resulting from mitigation activities. For REDD+, such a REL was developed using the Methodological Framework of the World Bank's Forest Carbon Partnership Facility (FCPF), which builds on IPCC methods. According to those guidelines, it should maintain consistency with the national GHG inventory. In the submission of Costa Rica's REL to the FCPF, the authors point out the country's need to guarantee that accounting of GHG fluxes in forests is sufficiently integrated to avoid double counting and inconsistent reporting. Since the NAMAs were still under development when the REL for REDD+ was established, consistency could not be fully guaranteed but all possible efforts to achieve the highest level of alignment were supposedly taken (Pedroni, Espejo, & Villegas, 2015).

According to the understanding of consultant 2, a future REL for the Livestock NAMA will be established in a separate process focused only on the specific policy intervention area. Methods used will most likely be distinct from the national GHG inventory because the MAG intends to develop the REL with cooperation projects and before the next actualisation of the GHG inventory in 2018. Since the retrospective integration into the next actualisation will

[4] The distribution of benefits mostly refers to the monetary transfers of performance based payments, received by a country for verified emission reductions or removals, to specific stakeholders, e.g. communities or households (Mohammed, 2011). Measured reductions and removals must be assigned to specific projects and actors in order to provide incentives for emission reductions (Luttrell et al., 2013).

probably cause difficulties, the GHG inventory may not reflect all emission reductions from the livestock sector in the future (ibid).

For the Coffee NAMA, Rojas et al. (2016) state that REL is established based on standards of the World Resources Institute, with no mention of REDD+ or the integration of methodologies. Consultant 3 confirms that the REL of the Coffee NAMA is not fully harmonised with REDD+ methodologies. Data gathered within the policy's intervention area is collected by the Coffee Institute of Costa Rica (Instituto del Café de Costa Rica) and then reported to the National Metrics System for Climate Change (Sistema Nacional de Métricas de Cambio Climatico) (ibid), which is in charge of the GHG inventory (consultant 2).

Due to the low level of alignment in the MRV methodologies in Costa Rica, the risk of double counting is increased. This may damage the environmental integrity of the mitigation mechanisms (Climate Focus, 2016). As a consequence, the effectiveness of both the NAMAs and the ENREDD+ could be reduced, indicating high potential for an adverse effect. The separate development of RELs for the NAMAs and REDD+ in Costa Rica may contribute to this effect. If NAMAs are not harmonised with REDD+ frameworks for RELs and their establishment is not streamlined, disparities in accounting may arise and compromise the accuracy of future performance-based payments under both mechanisms (Costenbader et al., 2013).

4.5.3 Efficiency

The efforts to develop an integrated national MRV system also bear potential for synergies, because streamlined responsibilities and successful integration would allow efficient communication and may save time and transaction costs (Costenbader et al., 2013). In a master's thesis comparing seven countries in Central America and the Caribbean, Costa Rica and Guatemala were found to have the best institutional infrastructure and high capacities for MRV. The Costa Rican National Meteorological Institute largely contributes to the beneficial structure due to its direct responsibility for the national GHG inventory reports. (Pacheco, 2017) Efficiency gains as a result of synergistic integration of MRV requirements may bear fruits in the future.

Increased efficiency through combining efforts of the NAMAs and the ENREDD+ can also cause synergies in other areas. The identification and prioritisation of zones that can generate REDD+ benefits as well as social and environmental co-benefits has only been explicitly stated in the PI-ENREDD+. However, after conducting a spatial analysis to identify prioritisation zones, García-Rangel et al. (2017) highlight that the information developed for REDD+ activities can be particularly interesting for Livestock NAMA activities since areas with high stocking rates can be found in some of those regions. This shows increased efficiency through the generation of spatial information useful for both policies. The information, in turn, can further increase efficiency through the eventual generation of multiple benefits by using this spatial information to implement the policies in prioritised zones. Ellison et al. (2017) confirm the importance of information on local differences by noting that "promoting positive synergies will require significant attention to geographic and environmental detail" (p. 58).

4.6 Socio-political interactions

4.6.1 Inclusiveness

A potential synergy can result from intended efforts of the ENREDD+ towards gender mainstreaming and increased participation of the youth. As instruments, the development of information, training, extension and financing activities for this purpose are mentioned. While there is a gender strategy for the entire agricultural sector under development (official 2), the Livestock NAMA also specifically includes stimulating the participation of the family and youth (EGBC). In this sense, the ENREDD+ and at least the Livestock NAMA may contribute to gender mainstreaming and the generational succession, indicating a potential synergy effect.

4.6.2 Communication strategies

Further potential for a synergy between the NAMAs and REDD+ activities can result from interactions of their information distribution and awareness campaigns. The Livestock NAMA includes the objective to increase the environmental awareness of consumers (NGCR) and the instrument to develop an information system (via web and radio) for farmers (EGBC). The Coffee NAMA broadly refers to the funding of other sensitisation activities (in addition to feasibility studies, capacity building and carbon audits) (Nieters et al., 2010). Those instruments may interact in a reinforcing manner with similar ones mentioned in the ENREDD+, including communication strategies to inform the civil society about the importance of forests for ES and about the Grievance Redress Mechanism[5]. Furthermore, awareness campaigns for forest fire control and for sustainably sourced wood are included. The PI-ENREDD+ adds to that a sensitisation campaign about the PPSA. While the details of most above mentioned communication strategies are still unclear, it is at least theoretically possible to streamline development and implementation of awareness campaigns and integrate the information for its spreading. Statements by officials 1, 2 and 3 confirm the need and plans for providing integrated information to farmers. The distribution of integrated environmental information through combined efforts presents a potential synergy which is supported by the national policy framework, since the construction of an environmentalist society is an objective of the PND.

4.6.3 Division between stakeholders of productive and environmental sectors

Currently, there is still a division in the Costa Rican population between conservative producers and radical conservationists (researcher 1), a common phenomenon in many regions of the world (official 1). Dissemination of integrated information and awareness raising, as part of the analysed policies, may help to overcome this dichotomy between exploiting trees and conserving them (researcher 1; official 1; official 2). The policy framework may also be supportive of this through an objective of the PND to construct an environmentalist society. Bringing together different private and public actors in the development and coordination of the policies increases communication and mutual understanding (official 2). The Roundtable on Livestock, for instance, creates dialog between public, private and international entities of the livestock sector as well as environmental

[5] A Grievance Redress Mechanism (GRM) is an organisational system of a public agency to receive and address feedback about the impact of its policies on external stakeholders. Countries participating in REDD+ are expected to establish or strengthen GRMs following a risk assessment for forest-dependent communities and relevant stakeholders (FCPF & UN-REDD Programme, 2015).

agencies like the FONAFIFO (ibid). While the FONAFIFO includes the REDD+ Secretary, involving and supporting the Roundtable is a policy instrument of the EGBC, and so is changing the conservative attitudes of some producers. The Roundtable thus constitutes a link between the livestock sector and officials involved in REDD+. Furthermore, by sharing results of the Livestock NAMA Pilot Plan, economic co-benefits resulting from mitigation measures can convince other producers to take conservation efforts (official 2; famer 1). Such efforts can include the participation of the PPSA, which is primarily an instrument of the PI-ENREDD+.

The ENREDD+ contributes to bridging gaps between producers' and environmental interests through its strong focus on productive systems, for example by increasing available credits and the number of extension agents. Furthermore, stated plans to move beyond restrictive efforts in agriculture and forestry, for instance through financial incentives, can increase producers' interests in conservation measures.

Additional conservation efforts on farms and associated image gains resulting from the harmonisation of different interests and increased collaboration between stakeholders may have a positive impact on the efficiency and effectiveness of policy implementation, representing a potential synergy between the Livestock NAMA and the ENREDD+. Another synergy in harmonising different attitudes of stakeholders can result from the complementarity of the approaches represented by REDD+ and the NAMAs. Noting the risk of "crowding out" the intrinsic motivation of some individuals for conservation efforts with the introduction of financial incentives, Kosoy & Corbera (2010) suggest to harness both long-term individual and collective conservation interests with and without financial incentives. Together, the PPSA as a financial incentive of the PI-ENREDD+ and voluntary capacity building events of the NAMAs may be successful in harnessing both individual and collective conservation interests.

4.6.4 Capacity building

Both NAMAs include as an important instrument the capacity building of producers and their associations. The EGBC particularly specifies the strengthening of producer associations and increasing their membership numbers. High capacities in the associations, in turn, facilitate the diffusion of information to their members (official 1; official 3; farmer 1; coffee processor 1). This is supported by the ENREDD+, which includes a joint plan by the environmental and agricultural sectors to provide information, training, technical assistance and agroforestry extension to smallholders and agroforestry producers. Integrated training and information on farm management and conservation practices were found to be desired by producers themselves (official 1; official 2; official 3). According to consultant 1, there is a single public organisation (CADETI) that is in charge of capacity building activities regarding technology transfer, agricultural practices and conservation areas. The common policy instrument of capacity building and the integration of information in training events for producers indicate a potential synergy from efficiency gains and an increased effectiveness of this instrument.

Similar effects are possible for the capacity building of officials. While the Coffee NAMA includes the capacity building of trainers such as extension officers, the EGBC refers to improving capacities of the state and to endowing MAG with the capacity to enforce sectoral policies. Again, the ENREDD+ shares the NAMAs' approach by including plans to train officials from MAG and the Ministry of Environment and Energy (Ministerio de Ambiente y Energía, MINAE) and strengthen their technical assistance and extension to support producers in issues of forest management and better practices. The PI-ENREDD+ further specifies the strengthening of capacities and assistance capacities of the MAG for agroforestry systems. The coherent instruments to increase public capacities may benefit the policies' effectiveness.

This potential for synergies is confirmed by Costenbader et al. (2013), who assert that in the integration of NAMAs and REDD+, capacity building is likely to be very important in capitalising on opportunities and mitigating weaknesses. It should be noted, however, that despite the reported usefulness of the capacity building events for low-carbon coffee production (coffee processor 1; farmer 3), only few coffee farmers participated in the past events (coffee processor 1; coffee processor 2). Synergies from integrated capacity building may thus remain unexploited potential.

The high institutional capacities that the implementation of the NAMAs and the ENREDD+ require may also lead to an adverse effect. If additional capacities are needed faster than they can be built, they may be acquired externally. According to consultant 2, since some officials are overwhelmed with coordinating the policies, they rely on the work of external consultants, which sustains or increases the lack of capacities in the ministries. This is confirmed by personal observations during this research, since various experts to which I was referred for specific information are external consultants.

4.6.5 Research and academic support

Another potential synergy may result from instruments to promote the participation of research institutes in all three policies. The Livestock NAMA builds on research on low-carbon livestock farming (EGBC) and on strengthening the participation of universities through the Program on Agricultural Research and Technology Transfer (NGCR). With and the Autonomous National University and CATIE, two universities provide technical support to the Coffee NAMA (Nieters et al., 2010). Similarly, the ENREDD+ refers to regarding AFS/SPS and in the brushing of knowledge on management, silviculture and the genetic improvement of species. Coherent references to the participation of research entities may strengthen a culture of scientifically informed policy making and promote the use of integrated knowledge. This can be called a meta-level synergy, since it may act as an enabling condition for other synergies, such as the use of integrated knowledge in awareness campaigns and capacity building. An example for research contributions is the promotion of studies and practices for low-impact land exploitation (ENREDD+). Furthermore, Smith et al. (2014) see the possibility of a synergy between research and development investments, as described above, and the development of integrated production systems, which is also promoted by all analysed policies in the form of AFS and SPS.

4.6.6 Interinstitutional coordination

Institutional arrangements of REDD+ require coordination across various government levels and agencies (Maniatis, Paz, Enters, DeVit, & Eggerts, 2017). The combination of NAMAs and REDD+ in forestry-related mitigation efforts increases the need for a communication channel between the respective agencies at national level (Costenbader et al., 2013). Describing mechanisms of cognitive interaction between institutions, Gehring & Oberthür (2009) assert that "information, knowledge or ideas produced within one institution may modify the perception of decision makers operating within another institution and thus significantly affect the decision-making process of this institution" (p. 132-133). Addressing the task of interinstitutional coordination is not only urgently need for the implementation of the land-use NAMAs and REDD+, the National Planning Law 5525 legally requires the state to act in a coordinated manner (PND). The EGBC includes establishing permanent exchange between sectoral organisations, MAG and FONAFIFO. It also states the objective to harmonise the interinstitutional coordination regarding linkages of the Livestock NAMA and the ENREDD+ in the framework for a national GHG inventory and the carbon neutrality programme. Similarly, the ENREDD+ includes the identification of mechanisms and actions for the collaboration of public entities, allowing the achievement of complementary goals within the framework of the PND.

Plans to improve institutional complementarity in the policy process may demonstrate two beneficial interactions. Firstly, the common objective to improve the coordination and collaboration between involved entities constitutes a potential synergy. Statements by officials 1 and 3 as well as consultant 1 confirm that the overlap of all three policies is significantly improving the cooperation of MAG with MINAE or FONAFIFO. Consultant 2 finds that a sectoral terminologies are converging as a result. Consultant 4 asserts that communication and language are key factors in policy integration. Secondly, the coordination of the policy process may facilitate additional synergies in all other areas and themes. This meta-level synergy on a higher organisational level both enables and is facilitated by synergies between individual instruments.

To name one example, a sequence of interacting instruments can build on existing synergy effects and create such meta-level synergies. Lambin et al. (2014) describe the complementarity of the following events: information campaigns to create awareness of an environmental issue, developing sustainable land-use standards (e.g. by research organisations) and financial instruments to enable affordable implementation (e.g. by PPSA investments). Potential synergies identified between the analysed policies suggest that the instruments described by Lambin et al. (2014) are not only complementary in the contributions that multiple policies make to each of those instruments, but also in their sum as subsequent events.

The coordination between institutions may also create a potential adverse effect. According to consultant 2, there are too many people involved in the coordination of REDD+ and the NAMAs. While this has improved technical cooperation, the management has worsened. As resulting issues the informant describes "blind proactivity" of involved actors and unproductive use of newly created communication space. Furthermore, individual institutions focus on deadlines much more than on coordination (ibid), thereby worsening this potential adverse effect.

4.6.7 Diversification of funding streams

Additional potential for synergy effects lies in the diversification of funding streams for AFOLU mitigation actions through both NAMA and REDD+ channels (Costenbader et al., 2013). The possibility to finance tree-based mitigation measures on coffee and livestock farms through

NAMA and REDD+ funding provides more flexibility and the option to follow both funding streams (ibid), thereby increasing planning security in the face of uncertain REDD+ financing. While the Livestock NAMA has no international donor yet (official 3), the development of the Coffee NAMA is supported with seven million Euros by the German Federal Ministry of Environment, Nature Conservation, Building and Nuclear Safety and the Department for Business, Energy and Industrial Strategy of the United Kingdom through the NAMA Facility (Nieters et al., 2010). Furthermore, the creation of a Coffee NAMA fund and financial incentives is intended (Rojas et al., 2016). Preparations for REDD+ implementation are funded by the FCPF (ENREDD+). Possible private investments in low-carbon forestry, coffee of livestock projects potentially provide additional sources of funding.

4.7 ES interactions in policy objectives

The overall objective of the Coffee NAMA to establish low-carbon coffee production includes reducing emissions from fertilizer use and coffee processing, but a strong focus lies on the promotion of shade trees on farms (Nieters et al., 2010). This demonstrates the importance of carbon sequestration (or climate regulation) as an ES targeted by the Coffee NAMA. Another objective explicitly stated in the policy documents is the preservation of natural resources such as soil and water (ibid), thereby including the maintenance and enhancement of the ES freshwater, water purification, water regulation and erosion control. The objective to maintain or increase productivity while emissions are reduced (ibid) refers to ES objectives for food production. Other anticipated effects resulting from trees on coffee plantations include enhanced biodiversity (ibid). Climate change adaptation as a stated co-benefit (ibid) implicitly targets various services, which is suggested by the recognition that ES “play an important role in reducing the vulnerability of people to climate change” (Pramova, Locatelli, Brockhaus, & Fohlmeister, 2012, p. 394). Regulating services that determine this central role of ecosystem management in adaptation include climate regulation, water regulation, water purification and pest control (Munang, Thiaw, Alverson, Liu, & Han, 2013). For the summary of how objectives and co-benefits of all policies have been operationalised for targeted ES in this research, see table 5 below.

Similarly, the Livestock NAMA includes the objective to increase carbon sequestration from growing trees on farms (EGBC). The objective of the EGBC and co-benefit of the NGCR to achieve higher productivity clearly target the ES food production. Enhanced water regulation, freshwater, erosion control, water purification and biodiversity are directly targeted as co-benefits in the LNC. The objective to improve climate change adaptation in livestock farming (LNC) implicitly builds on enhancing natural pest control.

The provision of all mentioned ES is also targeted by the ENREDD+, which includes the objective to capture and store CO_2, thereby targeting carbon sequestration. Further objectives are contributions to climate change adaptation and the creation of synergies in the sustainable management of water resources and degraded soils, biodiversity conservation and adaptation. In terms of ES, this implies the targeting of freshwater, water regulation, water purification, erosion control and pest control. Lastly, the objective of the PI-ENREDD+ to increase the application of AFS and SPS indirectly targets the ES food production.

All synergies between objectives to enhance these ES are supported by the National Development Plan, which identifies the increase of productivity as principal challenge of the agricultural sector (food production). It further refers to the objective to protect the health of animals from agrochemicals and pathogenic organisms. Another objective of the PND is to strengthen the conservation and sustainable use of the genetic and natural heritage as well as ecological and evolutionary processes. The protection of plants and animals from pathogenic organisms can be operationalised for ES with pest control and water purification, whereas the conservation of the genetic and natural heritage is translated into biodiversity. Further objectives include the development of good practices of community forestry, soil conservation, water and fire management to, e.g. to reduce surface flow, thereby implicitly but directly targeting erosion control, freshwater and water regulation as ES. All of those references themselves can be seen as part of the constitutional right of every person to an ecologically balanced environment in Costa Rica (PND).

Table 5: Operationalisation of policy objectives for targeted ES.

Policy (document)	Reference of objective and co-benefit	Operationalisation in terms of ES
Coffee NAMA (Nieters et al., 2010)	Production of low-carbon coffee	Carbon sequestration
Coffee NAMA (Nieters et al., 2010)	Preserve natural resources such as soil and water	Freshwater, water purification, water regulation and erosion control
Coffee NAMA (Nieters et al., 2010)	Maintain or even increase productivity	Food production
Coffee NAMA (Nieters et al., 2010)	Positive effects of trees on biodiversity etc.	Biodiversity
Coffee NAMA (Nieters et al., 2010)	Produce co-benefits including climate change adaptation	Pest control and others
Livestock NAMA (EGBC)	Capture CO_2 through sequestration capacity of the biomass on farms	Carbon sequestration
Livestock NAMA (NGCR)	Increased productivity	Food production
Livestock NAMA (LNC)	Protection of water resources and water retention	Freshwater and water regulation
Livestock NAMA (LNC)	Protection of hydric charge zones and larger riparian forest	Water purification
Livestock NAMA (LNC)	Improve climate change adaptation	Pest control, water purification, water regulation and others
ENREDD+	Capture and store CO_2	Carbon sequestration
ENREDD+	Create synergies in the sustainable management of water resources, degraded soils and biodiversity conservation	Freshwater, water regulation, water purification and erosion control
ENREDD+	Contribute to climate change adaptation	Pest control and others

PI-ENREDD+	Increase the application of AFS and SPS	Food production
National Development Plan (PND)	Protect the health of animals from agrochemicals and pathogenic organisms	Pest control, water purification
PND	Strengthen the conservation and sustainable use of the genetic and natural heritage as well as ecological and evolutionary processes	Biodiversity and others
PND	Develop good practices of community forestry, soil conservation, water and fire management to, e.g. to reduce surface flow	Erosion control, freshwater and water regulation
PND	Increase the agricultural value added, boosting an increase in productivity	Food production

As shown above, each of the mentioned ES are closely linked to objectives/co-benefits of the NAMAs' and are at the same time targeted by the (PI-)ENREDD+ and the PND. This indicates strong policy coherence in the policies' prioritisation of ES. Such a coherent prioritisation can be very useful in enhancing these ES, since they are inherently linked and can rarely be affected individually, as explained in chapter 2. Bundling ES has been described as one way to confront reductionist perspectives on them and optimise their provision (Kosoy & Corbera, 2010). Coherent ES related objectives of the policies provide clear signals for their implementation and may thus increase effectiveness in enhancing ES, constituting a potential synergy. Additional potential synergies result from the interaction of ES on the impact level and will be described throughout the remainder of this chapter.

4.8 Impact-level ES interactions

As described in chapter 3, there are different types of potential interactions between affected ES, i.e. interactions by policies affecting the same ES, affecting common drivers of change for ES and affecting different but interacting ES. While the typology helped identify interactions, for better clarity, impact-level interactions will be discussed below without reference of the specific types.

4.8.1 Freshwater & water regulation

Due to the many roles of the global water cycle, it is difficult to define it as a distinctly provisioning, regulating or supporting service (Vörösmarty et al., 2005). For this reason, both freshwater provision and water regulation are the ES used here to operationalise policy objectives for and impacts on the conservation of water quantity.

The common objective of the ENREDD+ and the Coffee NAMA to protect these ES is promoted by impact-level synergy effects. In fact, because of the important role of forests in protecting watersheds and smoothing out seasonal differences in river discharges (Shvidenko et al., 2005), instruments of all three policies to increase forest cover contribute to this objective.

Those instruments include dispersed trees, live fences and forest patches on livestock farms (LNC), shade trees on coffee plantations (Nieters et al., 2010) and various activities stated in the ENREDD+, e.g. reforestation on degraded land. The latter is reported to maximise groundwater recharge if intermediate tree densities are applied. Particularly dry-season flows are increased this way, which is more relevant for livelihoods in the tropics than annual streamflow. (Ellison et al., 2017) Exact impacts of increased tree cover on water availability depend on many factors, planting trees under consideration of the local circumstances may enhance water services (researcher 6). Agroforestry has been claimed to generally improve the conservation of water (Schroth & McNeely, 2011). In tropical AFS, water retention is enhanced since they increase the soil's infiltration capacity through litter input, while the provided shade decreases evaporation losses (Ellison et al., 2017).

Resulting from coherent instruments of all three policies, multiple impact-level interactions improving water regulation and the provision of freshwater indicate a potential synergy. However, depending on the exact implementation practices and geographic context, benefits to freshwater provision could be outweighed by a potential trade-off between increased forest cover and water availability. According to Smith et al. (2014), afforestation/reforestation is generally reported to reduce water yields in groundwater and surface catchments. Net water flow can decrease especially under young forests (Dudley & Stolton, 2003). Another trade-off is thus likely between freshwater yields and carbon sequestration on plantations (Jackson et al., 2005), since forest plantations are instruments of the ENREDD+ and the Livestock NAMA (EGBC; LNC).

4.8.2 Biodiversity

Biodiversity as another jointly targeted ES is also affected by instruments and implementation practices of all three policies, primarily by increasing forest cover. Higher tree density and diversity in coffee AFS increases bird community richness and diversity (Perfecto et al., 2004; researcher 6). Many fungi species are favoured by shade trees (Avelino, ten Hoopen, & DeClerck, 2011). Schroth & McNeely (2011) note that AFS can retain higher levels of biodiversity than mere plantations if native trees are used. Analogously, on cattle farms, SPS can enhance biodiversity (Harvey et al., 2014). Examples of implementation practices support those findings: farmer 1 noted new bird species on his pastures after planting trees, farmer 2 saw the number of observed animals increase after planting trees on his coffee plantation and pastures. Furthermore, avoided deforestation and re/afforestation, both objectives of the ENREDD+, may lead to maintained biodiversity (Smith et al., 2014). The pilot project of the Coffee NAMA includes a special PES modality that specifically encourages the planting of diverse and endangered tree species, which may eventually be adopted at the national level according to researcher 3. Such a modality is highly coherent with the plans stated in the PI-ENREDD+ to develop new PES modalities, specifically for AFS and SPS. This increases the potential of the described synergy between forest-cover related activities of the NAMAs and the ENREDD+ in enhancing biodiversity.

A significant part of the GHG emission reductions of the Coffee NAMA are expected from a more efficient use of fertilisers (Nieters et al., 2010). Similarly, the Livestock NAMA refers to the instrument of improved fertilisation plans (LNC). N-fertilisation may be further reduced by planting leguminous trees in AFS/SPS, since their N2-fixation capacity provides atmospheric N to nearby plants through litter and pruning input (Avelino et al., 2011). A very commonly used leguminous tree on farms in Costa Rica is *Erythrina poeppigiana* (researcher 5), shown in figure 9 (foreground). The decreased application of chemical fertilizers enhances water quality and ultimately aquatic biodiversity in the watershed (researcher 1).

Figure 9: Erythrina poeppigiana used for live fences on a cattle farm in Turrialba, Costa Rica.

According to researcher 7, approximately 30 percent of Costa Rica's forests are located on farms. Livestock farms alone contain 18.6 percent of the total forest area (MAG et al., 2015). Given that there is still high potential to increase this proportion (researcher 2; official 3; farmer 1), there may be a strong synergy between promoting forest and thereby biodiversity on farms through the NAMAs and the orientation of REDD+ efforts towards prioritised biodiversity conservation areas (ENREDD+). This is supported by Costenbader et al. (2013), who highlight the potential of NAMAs to fill the gaps of REDD+ on the landscape level. Dispersed trees on pastures, as promoted by the Livestock NAMA, are considered important in enhancing biodiversity by improved landscape connectivity (Harvey et al., 2011). Similarly, researcher 5 sees the possibility for REDD+ activities in Costa Rica to connect farms and create corridors. Connecting habitats by linking forests and farms with a forestry component may have positive impacts on many species. For instance, species richness of non-flying mammals on coffee plantations contiguous of forest remnants was found to be the same as in forest reserves, but was much lower on other coffee sites (Daily, Ceballos, Pacheco, Suzán, & Sánchez-Azofeifa, 2003). Ant species richness on a plantation decreases with a higher distance from forest fragments (Avelino et al., 2011).

Conserved or additional forests can also provide habitat for insects that prey on pests and serve as a barrier for diseases (researcher 1; researcher 4; researcher 6) that might otherwise affect nearby coffee and livestock farms. Similar effects can be expected from AFS and SPS on the farms, which will be explained in the following subchapter. Through this mechanism, REDD+ efforts can reduce the need for pesticides on those farms. Intensive pesticide use would lead to the loss of beneficial organisms (Avelino et al., 2011), reduced pesticide use through enhanced pest control by forests would thus enhance biodiversity (researcher 1; researcher 2; researcher 6). This is complemented by improved pastures as an instrument of the Livestock NAMA to increase productivity (CNFG), which have the co-benefit of reducing the need for herbicides (farmer 1). Consequently, landscape-level interactions of maintaining or increasing forest cover may benefit invertebrate biodiversity on farms (researcher 1). As with reduced N-leaching from more efficient fertilisation, this also improves aquatic biodiversity in surrounding water bodies (ibid).

Potential ES impacts described above demonstrate a strong potential synergy between the NAMAs and the ENREDD+ in enhancing biodiversity. In many instances, due to the significant role biodiversity plays in the provision of tropical forest ES (De Beenhouwer, Aerts, & Honnay, 2013), it delivers benefits to humans indirectly. Biodiversity is at the basis of all ecosystem processes and therefore the provision of all ES depends on the presence of biodiversity (Mace et al., 2005). The impacts of enhanced biodiversity on other ES will be illuminated in the following sections.

However, not all potential interactions affecting biodiversity are synergistic. In the implementation of the Coffee NAMA, there is a practical limit regarding the number of species used for shade trees, whether it is leguminous or fruit trees. Too many species on a plantation are economically undesirable because of smaller sales volumes per fruit and complicated procedures for pruning (researcher 1). For similar reasons, the specific implementation practices of Livestock NAMA instruments (live fences, etc.) may effectively limit the number of tree species on pastures. Livestock farmers mostly have a preference for one or two tree species, which are then used almost exclusively for live fences, such as the aforementioned *Erythrina poeppigiana* (researcher 4, researcher 5; personal observations). Those impacts of NAMA implementation practices conflict with expected ENREDD+ impacts, indicating a potential trade-off between impacts on biodiversity (and food production).

4.8.3 Pest control

Pest control is an important ES in helping to achieve the adaptation objectives, since the rapidly warming climate and changing weather extremes are likely to affect the regional incidence of pests (Rosenzweig, Iglesias, Yang, Epstein, & Chivian, 2001) and reduce the plants' capacity to resist and recover from pest and disease outbreaks (Jump & Peñuelas, 2005). Pest control is also important in maintaining or increasing food production (Avelino et al., 2011), a common objective of the NAMAs. Beyond mere objectives, potential policy impacts of both NAMAs and of the ENREDD+ may synergistically increase natural pest control. Although the process is extremely complex and poorly understood (ibid), biodiversity generally increases pest resistance (Avelino et al., 2011; Ellison et al., 2017). Diverse agroecosystems are commonly thought to increase pest control through the high diversity of natural enemies they support (Perfecto et al., 2004). The expected positive policy impacts on biodiversity described in the previous subchapter may thus also enhance pest control. This includes the predation of insect herbivores by rich bird communities (De Beenhouwer et al., 2013; Perfecto et al., 2004; researcher 6) and the positive impact of shade trees on many fungi and ant species that in turn may improve pest control (Avelino et al., 2011). Contributions of biodiversity to the natural control of pests decrease the need for chemical pesticides, which in turn leads to additional biodiversity benefits, suggesting a positive feedback loop as figure 10 illustrates.

Furthermore, as I briefly mentioned in the previous subchapter, the introduction of non-host vegetation on farms through AFS/SPS, promoted by all policies, may intercept pests and diseases. While shade trees in tropical AFS are potential barriers to pest spread, insect dispersal is particularly influenced by windbreaks and live fences. Trees have also been shown to intercept rainfall and reduce impact intensity and thus splash dispersal of pathogens. Shade trees on coffee farms provide additional pest control as some pests and diseases cause more intense epidemics when yield is high, which is often the case in full sun exposure. The introduction of N2-fixing leguminous trees can lead to increased pest resistance through improved plant resistance as a result of better nutrition (Avelino et al., 2011). The ENREDD+ further contributes to pest control through the already mentioned barrier effect of forests.

Despite indications that the NAMAs and the ENREDD+ may all have beneficial impacts on pest control, which suggests a potential synergy, specific circumstances may also lead to contrary results at least on coffee plantations. This is owed to the complexity of interactions between pest control and biodiversity, and to the usually unclear overall effects of shade trees on pests and diseases. Some pests are favoured by microclimatic conditions on shaded plantations, and the coffee berry borer, for instance, can find refuge in fruit trees. With shade hampering one noxious organism and favouring another, the balance of such antagonistic effects on pest control is often variable and controversial (Avelino et al., 2011).

4.8.4 Water purification

Low water quality negatively affects water purification due to the limited capacity of ecosystems to purify wastes (Millennium Ecosystem Assessment, 2005). Policy impacts improving water quality consequently enhance water purification. This ES is therefore used here to operationalise policy objectives and impacts targeting or affecting the quality of water resources. Analogously to the provision of freshwater and water regulation, maintaining and enhancing water purification is considered to be included in the common policy objective to conserve water resources. It has already been established above that positive policy impacts on pest control that reduce the need for pesticides can improve water quality. Efficient fertilizer use and impacts that reduce the need for fertilization further contribute to enhancing water purification through reduced nitrate leaching. The improved water quality, in turn, enhances biodiversity (researcher 1), which then further enhances natural pest control (Avelino et al., 2011). This may again reduce pesticide use, extending and strengthening the positive feedback loop of enhanced biodiversity, pest control and water purification (see figure 10).

While such impacts enhance water purification indirectly, others contribute to the ES more directly. Forests are said to maintain water quality (Shvidenko et al., 2005), maintained or increased forest cover as a result of the Livestock NAMA or the PI-ENREDD+ may thus enhance purification. Reforesting degraded watersheds, for instance, as an objective of the PI-ENREDD+, can restore water quality (Smith et al., 2014) and thereby enhance purification. All potential impacts of the three analysed polices on water purification suggest the possibility for a strong impact-level synergy.

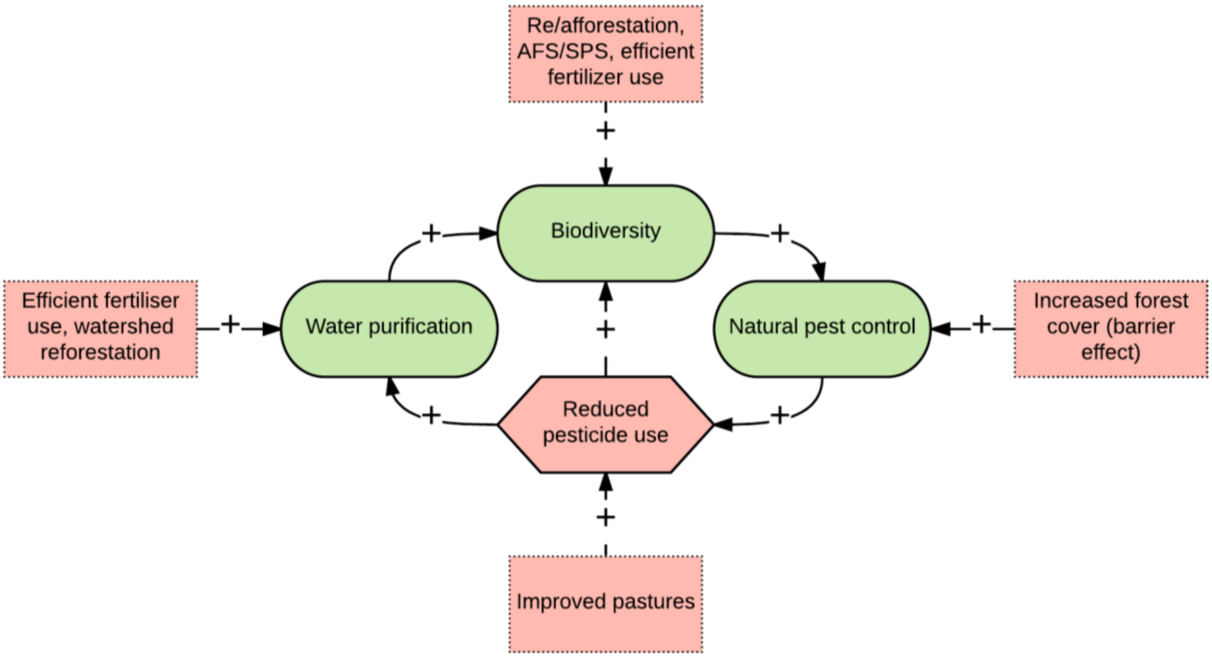

Figure 10: Positive feedback loop of ES interactions potentially enhanced by policy impacts.

Increased forest cover and the implied enhancement of carbon sequestration can also conflict with water purification if invasive tree species are used. An example is *Acasia Pennatula*, which provides timber and forage, but is often fought by farmers with herbicides (researcher 1) because of the uncontrolled dispersal of its seeds by cows. If this species is used to increased tree cover, a trade-off can occur between carbon sequestration and water purification resulting from the herbicide input.

4.8.5 Carbon sequestration

While recognizing the climate regulating role of forests through emitting organic compounds and water vapour (Ellison et al., 2017), this section is focused on forests' contributions to enhancing climate regulation through carbon sequestration. Avoiding losses of forest carbon and promoting increases, thus enhancing carbon sequestration, is clearly the primary objective of the ENREDD+. Maintaining and enhancing forest carbon stocks is also an important objective of the Livestock NAMA (LNC) and co-benefit of the Coffee NAMA (Nieters et al., 2010). Inversely, soil conservation as another way of enhancing carbon sequestration is stated as an objective of the Coffee NAMA (ibid) and co-benefit of the Livestock NAMA (LNC). The restoration of degraded land as an objective of the PI-ENREDD+ also contributes to soil conservation. Beyond the apparent alignment of the policies in targeting carbon stocks in soil and biomass, various policy instruments have potential impacts on this regulating service. Indirect impacts include the common enhancement of natural pest control, which may mitigate the impacts of *Hemileia vastratrix* (coffee leaf rust) and thus contribute to the permanence of carbon stocks in the biomass (researcher 4). Jointly enhanced biodiversity may also lead to higher carbon sequestration, because biodiversity enhances tree growth (Ellison et al., 2017) and biomass is produced more efficiently with more diverse tree communities (De Beenhouwer et al., 2013).

Other policy instruments affect carbon sequestration directly, such as improved control of forest fires, which helps conserve existing carbon stocks (Smith et al., 2014). Forest fires are an important cause of forest degradation and carbon emissions in Costa Rica (García-Rangel et al., 2017). During the period between 2013 and 2015, an area of 760.478 km2 was reported to be affected by fires (ibid). REDD+ contributes to fire control through various instruments, such as operational and financial strengthening of the strategy for fire management and forest fire control of SINAC[6], sustainable management of water resources, the reduction water stress in Guanacaste (ENREDD+), strengthening of programmes for the prevention and control of forest fires, and strengthening community control of forest fires (PI-ENREDD+). The NAMAs may improve forest fire control through the common objective to preserve water and their described instruments contributing to its achievement. For instance, trees (in AFS and SPS) increase water availability during the dry season (Ellison et al., 2017). Furthermore, most fires originate on farms from burning weeds or parasites (researcher 1). Improved pastures as an instrument of the Livestock NAMA can decrease the amount of weeds and thus reduce the driver of forest fires. Indirectly, the enhanced pest control as a potential impact of all policies may further decrease this driver through the reduced occurrence of parasites. In sum, both NAMAs and REDD+ may increase the permanence of carbon stocks by contributing to the prevention and control of forest fires. Furthermore, objectives of the NAMAs to create socio-economic co-benefits are promoted through REDD+ instruments to control forest fires by protecting the farms' infrastructure (researcher 6).

Sequestered carbon is not only maintained but also increase by the Coffee NAMA through the promotion of and financial support for AFS, particularly for the introduction of new tree species on coffee farms (Nieters et al., 2010). Beyond the increased carbon sequestered in trees, this includes enhancing soil carbon stocks, since AFS provide additional benefits for soil conservation (Schroth & McNeely, 2011) and plant diversity improves physical and physical and chemical soil characteristics (Avelino et al., 2011). Where live fences planted through the Livestock NAMA serve as windbreaks, they can reduce erosion and the loss of soil carbon (Smith et al., 2014). Rotational grazing as another Livestock NAMA instrument further contributes to soil conservation and carbon stocks (LNC). Such NAMA impacts are reinforced by impacts of REDD+ activities, for instance a range of instruments contributing to capacity building in the management and promotion of forestry and plantations for increased competitiveness (ENREDD+). If those deliver the expected results, soil carbon is maintained because forests can protect landscapes from soil erosion (Shvidenko et al., 2005). Coherent impacts of all policies enhancing carbon sequestration indicate clear potential for a strong synergy effect.

Reports indicate that in Rwanda, a programme for the regularization of land tenure had a very large impact on soil conservation (Ayalew Ali, Deininger, & Goldstein, 2014). If contextual similarities with the situation in Costa Rica allow for this comparison, there is also potential synergy between enhancing soil carbon stocks and the clarification of land tenure rights. The latter is an objective of the PI-ENREDD+, but clarified and harmonized land tenure and land-use rights are also reported as possible co-benefit of AFOLU mitigation (Bustamante et al., 2014), depending on institutions and their level of enforcement (Smith et al., 2014).

[6] SINAC: Sistema Nacional de Áreas de Conservación (National System of Conservation Areas)

In certain cases, increased carbon sequestration conflicts with the enhancement of other ES. Areas of high carbon content do not necessarily coincide with high-biodiversity areas (Kosoy & Corbera, 2010; Smith et al., 2014). Increasing carbon sequestration through high density tree monocultures, for instance, can reduce biodiversity (Beer et al., 2003; Hirsch et al., 2011).

Comparing coffee production systems of different (input) intensity in Costa Rica, Noponen, Haggar, Edwards-Jones, & Healey (2013) found indications for a strong trade-off between carbon sequestration and food (i.e. coffee) production on the farm. Most of the analysed shaded production systems showed lower productivity than full sun systems. Hence, a potential trade-off exists between the Coffee NAMAs objective to maintain or increase production and the expansion of the PPSA for carbon sequestration as part of the ENREDD+, although it can also be seen as a trade-off within the Coffee NAMA.

Young trees are harder to establish on improved pastures due to their strong root system and competition for water (researcher 1). Certain tree species were reported to have a detrimental impact on the pasture (farmer 2). This suggests a potential trade-off between improved pastures as an instrument of the Livestock NAMA (LNC) and the implementation practice of the PI-ENREDD+ to plant trees on pastures for carbon sequestration.

Another potential trade-off is identified between co-benefits of the tree species *Erythrina poeppigiana* for soil conservation, water regulation, reduced N-fertilisation, etc. and its relatively low carbon content (researcher 5). While this is another interaction that also occurs within the NAMAs, it can be relevant as a conflict between the co-benefits of the NAMAs and the carbon sequestration objective of the (PI-)ENREDD+.

4.8.6 Pollination

A synergy often mentioned in literature is the positive effect of forest patches on nearby farms, enhancing pollination and consequently the production of crops (De Beenhouwer et al., 2013) such as coffee (Bennett et al., 2009; Shvidenko et al., 2005). In a similar way, agroforestry itself retains more pollinator organisms than monocultures do (Schroth & McNeely, 2011). Instruments such as the promotion of AFS by the Coffee NAMA and the creation of forest patches through both the PI-ENREDD+ and the Livestock NAMA can all contribute to enhancing pollination and thereby also increase food production.

4.8.7 Dependence on geographical context

Many potential ES impacts of the analysed policies will be determined in the future by implementation practices and the geographic context. It is thus important to note that considerations of affected ES are highly dependent on the potential of the land to generate these services. All plans to create or exploit the many possible synergies between ES impacts should therefore be informed by spatial analyses that provide indications for where multiple ES can be enhanced.

The PI-ENREDD+ is informed by such a spatial analysis has been conducted by García-Rangel et al. (2017) to identify potential implementation areas with the spatial convergence of multiple benefits beyond climate mitigation. Six out of seven of these benefits either constitute or are closely related to one or more ES. The determination of priorities for the benefits has been set out in Costa Rica by the Forestry Law (Nº 7575, 1996), the Law on Land

Use, Management and Conservation (Nº 7779, 1998) and preparation processes for REDD+ carried out in the country. The six ES benefits cover mitigation of GHG (climate regulation), natural scenic beauty for touristic purposes, biodiversity conservation, support of communities vulnerable to water stress (freshwater, water regulation), potential for socioeconomic improvement (production of food and fibre) and control of soil loss from erosion (erosion control). (García-Rangel et al., 2017)

Results show that the largest convergence of benefits can be found in protected forest areas and indigenous territories. In all eight regions of Costa Rica, forest areas can be identified on which five or more benefits converge. While this means that the introduction of incentives for sustainable forest management and conservation is relevant for all regions, it also shows the need for compromises in the prioritisation of areas. Huetar Norte as the region where seven benefits converge, as well as Huetar Caribe and Brunca with large areas of high convergence, could be of special interest. The expansion of the PPSA to generate above mentioned incentives can be particularly useful in forests that both provide multiple benefits and are also under risk of future deforestation and degradation. (ibid)

Considering the importance of AFS in the national context, García-Rangel et al. (2017) conducted another spatial analysis to assess the potential convergence of multiple benefits in the agricultural sector. This analysis covered in terms of benefits, inter alia, the support to communities at risk of water shortage, potential for socio-economic improvement and the control of water erosion. Benefits related to GHG mitigation and biodiversity conservation could not be analysed due to a lack of suitable spatial information. The introduction of AFS as part of the REDD+ implementation can generate the included benefits on approximately 12.500 km^2. The regions of Brunca, Huetar Norte, Huetar Caribe and Chorotega can be important for the introduction of AFS in a REDD+ context (ibid).

Although exploiting synergies and multiple benefits is generally not the same, both can be linked and mutually supportive. Potential synergies can be exploited by prioritising areas of spatially converging benefits and those benefits can be increased and exploited by creating synergies and reducing trade-offs. Policy instruments promoting forest conservation and AFS/SPS identified in this research can generate multiple benefits if implemented on areas of spatial convergence, while at the same time create synergies as described in the respective subchapters (4.2 “Interactions regarding forest conservation” and 4.3 “Interactions regarding agroforestry and silvopasture systems”), which partially overlap. The availability of spatially explicit information is key for exploiting this meta-level synergy.

4.9 Summary of results and concluding remarks

A large number of synergies, various trade-offs and a few adverse effects have been identified. In general, it can be said that the policy documents are very coherent, i.e. the consistency of stated policy objectives and instruments allows for a plethora of synergies. Many objectives and intended instruments to achieve them are common to all policies.

Although potential interactions have been found within and among all policy layers, interactions between policy instruments appear more often than others. This may relate to the fact that at the time of investigation, detailed information was mostly available on this policy layer. Another explanation is that instruments are generally relatively concrete policy components. Results of the coherence analysis revealed a large variety of instruments mentioned in the policy documents that are able to reinforce each other. Furthermore, the possibility for producers to implement individual mixes of policy instruments creates potential for many synergies, such as reforestation and the restoration of degraded land, reduced fertilizer use and crop diversification, or community control of forest fires and the conservation of water resources by increasing infiltration and retention capacities with trees. Another way for instruments to interact is through what I called meta-level synergies, for instance by allowing for complementarities on a larger time scale or higher institutional level.

Arguably the most severe trade-off results from the specific land-use types that are promoted by the policies differs. Agricultural NAMAs, such as the ones analysed, inherently favour agricultural development which tends to conflict with the forestry sector. However, the policies' focus on AFS and SPS as common ground of both sectors exhibits somewhat optimal exploitation of synergies between the different interests. Simultaneously increasing the competitiveness of forestry and (tree-based) agricultural land use may be seen as a conflict of the policies' individual objectives. Perhaps more importantly, it may be considered a synergy of the policies common objective to improve both sectors' relative competitiveness compared to "third" land uses that may pose larger threats to AFOLU mitigation efforts in the long term. Those include for example price developments of products such as melon and pineapple (ENREDD+).

Despite the apparent efforts to align the policies and to cooperate in the policy process and implementation, potentially severe trade-offs and adverse effects have been identified resulting from the complex policy process. Involved policy makers seem highly aware of the need to integrate the policies and capitalise on synergy effects in the restoration of degraded land, low-carbon marketing, the conservation of natural resources and the role of the PPSA. Nevertheless, the coordinative task of putting such ideas into practice may overwhelm national capacities and lag behind the positive intentions. Negligence of properly integrating the policies' MRV requirements and streamlining the development of RELs add to the resulting potential for detrimental interactions such as increased risk of double counting national emission reductions.

Prioritisation of ES, in contrast, has evidently been addressed quite effectively. Results of the analysis for interactions of potential ES impacts have demonstrated a high level of coherence. The same ES have been targeted by the NAMAs, the ENREDD+ and the PND representing the policy framework. Consequently, the relationships among affected ES and thus the potential impact-level interactions are found to be mostly positive. Various synergies can result from a particular ES enhanced by one or more policies that may positively affect another ES. In other cases, ES may be directly improved by one or multiple policies. This can lead to a chain of mutually enhanced ES and even positive feedback loops. Trade-offs on the impact level have been identified to possibly result from specific implementation practices that are not compatible with ES objectives under certain circumstances. Uncertainties in and the complexity of ES interactions may cause additional trade-offs, but adverse effects have not been identified between ES impacts.

Most of the results represent a consensus among the experts that were consulted regarding specific interaction themes. Disagreements that I came across throughout the consultations were resolved using the concept of the Delphi method. Nonetheless, the interviews revealed some disagreements and contradictions that still remain. For example beliefs varied whether the complex process of integrating the policies will prove beneficial for mitigation impacts. There was disagreement about the level of cooperation between involved public actors and the extent to which it is fruitful. Furthermore, experts disagreed about the potential of the Coffee NAMA to enhance biodiversity, which would affect interactions with ES impacts of the ENREDD+. As mentioned before, there was also a discrepancy in estimations of degraded pasture areas in Costa Rica. This is emblematic for different opinions on the role of cattle farming in reforestation and landscape restoration discovered during the interviews. In terms of interactions, this leads to uncertainties about the exact potential to restore degraded land by planting trees on livestock farms and to increase forest cover through higher farm productivity.

5. Conclusion

Given the important role of the AFOLU sector for climate change mitigation and the provision of other important ES, the amount of respective policy options is increasing. This, in turn, challenges the effectiveness of such policies since they interact in complex ways if implemented simultaneously. In order to manage interactions and increase effectiveness, they need to be identified through appropriate policy analyses. For this purpose, a methodological approach has been developed here to facilitate comprehensive coherence analyses, which was applied to the case of Costa Rica's AFOLU mitigation policies.

In concluding the results of the conducted analysis, presented in the previous chapter, I pose once again the central research question guiding the analysis that led to these results:

> *"What are potential interactions between the Costa Rican Coffee and Livestock NAMAs and the National REDD+ Strategy and Implementation Plan, and between their impacts on ES?"*

The answer to this question is found in the aggregate of synergies, trade-offs and adverse effects presented as results. Significantly more synergies have been identified than trade-offs. However, due to various interacting components within specific themes, is often still unclear whether the synergistic or conflicting quality of an interaction will prevail. Only few adverse effects are found and they all relate to the layer of policy processes, where the integration of the policies challenges institutional capacities. Synergies and trade-offs, in contrast, appear to mostly occur between policy objectives, instruments and ES impacts. Most objectives are highly synergistic, particularly those that directly or indirectly target specific ES. Many objectives are jointly pursued by multiple policies, however, some are inherently incompatible and require prioritisations on a higher level to avoid trade-offs. Instruments of the three analysed policies are also very often employed by multiple policies, causing various synergies between them. To a similar extent, synergies between instruments occur as a result of their high compatibility (e.g. the PES scheme and AFS/SPS). On the level of (potentially) affected ES, the vast majority of identified interactions is synergistic, which in part is based on the coherent formulation of objectives and instruments. Surprisingly, in the context of the analysed policies, biodiversity and carbon sequestration are among the selected ES that benefit most from synergies among services, although this does not necessarily result from direct positive interactions between the two. Another set of various synergies result from the positive feedback loop between water purification, biodiversity, pest control and reduced pesticide use. This prompts the conclusion that a strong institutional framework focused on the conservation of selected ES facilitates the alignment of sectoral policies. No-regret policy instruments that are compatible among one another and serve multiple national objectives weight heavily in coherence analyses.

5.1 Answer to sub-question 2

In order to recapitulate the methodological approach taken, I briefly return to sub-question 2:

> *"What is a useful methodology to examine complex interactions between AFOLU (mitigation) policies?"*

Testing the developed methodology with the case of land-use NAMAs and REDD+ in Costa Rica revealed that a comprehensive and interdisciplinary coherence analysis, focussing on all policy layers, presents a useful approach to examine complex interactions of AFOLU policies. The concept of policy coherence and the ecosystem services approach have proven very valuable in combining social and ecological knowledge. Through the comprehensive policy coherence approach, a large variety and number of potential synergies, trade-offs and adverse effects was identified that might have otherwise remained opaque. This plethora of interactions was identified along the entire policy cycle, including the policy process with interactions of institutional arrangements, policy outputs with interactions among objectives, instruments and implementation practices and policy impacts with interactions among affected ES. Integrating an ecosystem services approach thus contributed to the comprehensive character of the coherence analysis by enabling the identification of interactions that fall outside the traditional policy realm. The methodology further benefits from the combination of a literature review, content analyses and interviews. Combining different kinds of methods and data is found to strengthen a study, because it increases the generalisability of results and possible exceptions (mismatches of data) can be used to improve theories (Golafshani, 2003). Such triangulation has been described as "a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study" (Creswell & Miller in Golafshani, 2003, p. 604).

5.2 Answer to sub-question 3

Findings further enable answers to sub-question 2 of this research, which was formulated as follows:

> *"What is the role of the broader policy context in creating and exploiting synergies and minimising trade-offs and adverse effects?"*

Prior to any policy process, our ability to maximise synergies and reduce trade-offs and adverse effects is limited by the lack of information on the specific policy outputs. At that stage, institutional coordination and streamlined responsibilities create a favourable environment that allows for many synergies. A strategic and integrated policy framework can be very helpful by providing a general idea on how individual policies may or should reinforce each other. Bringing involved actors on the same page before the policy process and indicating a vision of the bigger picture can improve future coordination.

5.3 Answer to sub-question 4

Presented results allow to answer research sub-question 4, which had been formulated:

> *"What are lessons learned from this specific case that may guide the implementation of similar policies in countries of Latin America and the Caribbean?"*

The lessons learned and policy recommendations distilled from this study are presented in subchapter 6.4. They include the finding that an integrated and strategic formulation of the national policy framework with clearly prioritised ES and a focus on generating synergies in implementation may in fact lead to improved coherence of sectoral policies. Furthermore, during the early stages of developing new AFOLU policies, the default conduct of coherence analysis with related policies can help address potentially occurring interactions. The adherence of all AFOLU mitigation policy processes to common methodologies for emission accounting as well as streamlined responsibilities are an important but challenging task. Distilling recommendations from this study, it seems helpful in the integration of AFOLU mitigation policies for them to be coordinated by a central organ responsible for all climate change relate policies. Agroforestry and silvopasture systems constitute a very potent instrument for AFOLU measures to enhance various ES, but exact implementation practices need to reflect the national ES priorities.

6 Discussion

Interactions in the policy processes between the analysed policies are often detrimental to the effectiveness of one or more policies. The NAMAs and REDD+ are treated as linked but (conceptually) distinct policies and their implementation takes place formally separate. Such an approach is at discord with recommendations of Costenbader et al. (2013), who advocate either thorough integration or the omission of forestry-based NAMAs if REDD+ implementation is pursued. Thorough integration would require, for instance, the same REL for REDD+ and NAMAs as well as the application of the same safeguards, all of which is not the case in Costa Rica. Since this is in part owed to the more advanced implementation stage of REDD+, adjustments in the future may still increase the level of integration.

The both synergistic and conflicting interaction of simultaneously aiming to increase the competitiveness of forestry and agroforestry/silvopasture land uses transcends any coherence debate regarding the land-use NAMAs and the ENREDD+. The notion of policy coherence itself in terms of aligning different policies is limited by larger nationally determined priorities or a lack thereof. Mickwitz et al. (2010) use the term policy coherence to imply that there are no conflicting signals in the incentives that different policies provide target groups with. But even if consistency is addressed, there can remain fundamental conflicts between climate change mitigation aims and other policies, which are only resolved if climate aims receive overriding priority (ibid). Limits to the coherence of the Livestock NAMA and the ENREDD+ regarding their impacts on sectoral competitiveness are thus not necessarily a result of insufficient policy integration but rather of development prioritisation, which has not been addressed effectively.

6.1 Limitations of the research

The collection of potential interactions identified in this research should by no means be understood as exhaustive. It merely represents the most apparent and agreed-upon interactions and is contingent on, inter alia, the limited scope of this research, specific findings from the literature review, the selection of considered ES, the availability and contents of policy documents, the knowledge and opinions of the informants and my own experience and perspective. Moreover, many policy instruments are part of both the NAMAs and REDD+, meaning the same combination of instruments is found in policy documents of multiple policies. Interactions between these exact instruments do not necessarily require another policy to occur and therefore may also take place (to a lesser extent) within an individual policy.

Given that all analysed policies are still at an early implementation stage, the conducted research exhibits characteristics of an ex-ante analysis. This implies some inherent limitations, most importantly remaining uncertainties regarding final institutional arrangements, the lack of implementation practices to examine and little knowledge on policy impacts. Therefore, it is too early to be able to determine some interactions which are yet to emerge and develop their specific qualities. Many outcomes remain unclear, specifically the behavioural responses of affected actors (e.g. producers) and the medium- to long-term impacts of structural changes (e.g. institutional coordination). Particularly the identification of policy interactions on the level of affected ecosystem services is limited by the fact that ES impacts are mainly derived from policy instruments and from scientific literature. Uncertainties remain regarding contextual factors and unexpected policy outcomes, for example climate change impacts and rebound effects. Ultimately, the actual occurrence of interactions will also depend on the uptake of voluntary instruments and context-specific implementation practices of targeted actors. Most interactions presented here are thus described in terms of their potential to occur.

While the selection of considered ES was based on policy priorities in Costa Rica, as described in subchapters 3.2 and 4.7, terminological differences leave some leeway to the research design. References to targeted ES in the policy documents vary at least in two ways, namely in their relevance (i.e. objective or co-benefit) and in their explicitness (e.g. biodiversity conservation, preservation of water resources and climate change adaptation). Furthermore, with a broader scope more ES could have been included in the research, even though they would be less relevant in terms of policy priorities and impacts on them would be lower.

In the chapter on forests of the Millennium Ecosystem Assessment, Shvidenko et al. (2005) make the very important remark that the "multiservice paradigm of forest management […] frequently requires difficult choices and trade-offs" (p. 600). There are two possible implications on the discrepancy between the assertion by Shvidenko et al. (2005) and my findings regarding synergies between ES impacts. It could be an indication for an analytical bias in favour of synergistic ES interactions. This may result from a focus on synergies rather than trade-offs by the informants or a similar tendency in the reviewed body of literature as Mickwitz et al. (2010) had also noted. Efforts were taken to avoid a personal bias (towards certain interaction types and qualities), but they can hardly ever be excluded with certainty. An alternative explanation for the relative dominance of synergies between potential ES impacts may be a favourable prioritisation of services in the Costa Rican policy framework. Targeting specific ES through suitable instruments that can help in enhancing them simultaneously may have led to mostly synergistic potential interactions between services affected by AFOLU policies.

In quantitative studies, the concept of reliability is used to ensure consistency of the measurements and the replicability and repeatability of the results. Due to the different purpose of qualitative studies, which aim to shed light to an otherwise confusing or enigmatic situation, the concept of reliability becomes irrelevant here. For qualitative research, the questions of reliability and validity posed in quantitative research are reported to translate into concepts like applicability and credibility. A study's credibility depends on the ability and effort of the researcher. (Golafshani, 2003) Reflecting on my efforts and abilities to conduct the this research, it seems that starting with high efforts led to a strong learning process which eventually created sufficient abilities to do justice to the concept of credibility. Reflections on the validity or applicability require a more differentiated perspective. Through the triangulation of methods and data, validity or rigor in the present analysis may be determined by the degree to which information from the three kinds of sources converges within themes of the results chapter. While the developed methodology can be applied for any analysis of multiple AFOLU policies, the results are more context specific and thus mainly serve to guide policymaking in the Neotropics. The remainder of this chapter gives a more detailed presentation of the applicability of this research.

6.2 Contributions to theory

Despite all limitations, this research provides new insights for policy analysis and important implications for the management of policy interactions. The intentions of a qualitative study, like the present one, are not to seek prediction and generalisation but rather "illumination, understanding, and extrapolation to similar situations" (Golafshani, 2003, p. 600). Hence, the findings of this research may be regarded as an effort to illuminate the complex and indirect impact of policy interactions on their effectiveness. Before recommendations for future research and AFOLU policy making are laid out, this section show how the developed methodology and the interactions identified expand current theories.

Conclusions of this study support findings from literature that paying attention to impacts on ES in AFOLU policy analysis is a very useful approach to enable the effective governance of vital services. Taking into account interactions of AFOLU policy impacts on these ES goes one step further and provides even more detailed information on how prioritised services can be enhanced efficiently and effectively. A broad interdisciplinary approach, based on the concepts of policy coherence and ES, with triangulation of methods and data provides a comprehensive methodology to examine the complex AFOLU policy interactions and thereby fills a gap in the current theory on policy analysis. It constitutes an analytical tool that can be applied in different contexts to identify potential interactions between AFOLU mitigation policies from a social and ecological perspective. Policy interactions are highly relevant for the effectiveness of AFOLU policies. Mainstreaming their identification and consideration at the science-policy interface can improve the usefulness of AFOLU policy analysis.

Beyond a new field for policy analysis and the development of a pertinent methodology, findings of this research enable the adaptation of some theories on policy integration and ES interactions. Costenbader et al. (2013) indicate that integration of land-use NAMAs and REDD+ in countries with low institutional capacities can cause excessive complication and confusion. Pacheco (2017) noted comparatively high institutional capacities for MRV in Costa Rica. Yet, this study revealed that even Costa Rican policy makers show a high degree of frustration from the complexity of the integration process. The slow progress with the national MRV system suggests that involved actors are in fact excessively confused about the process. The theory of Costenbader et al. (2013) may thus require adaptation in order to specify that even for countries with relatively high institutional capacities, efforts to integrate NAMAs and REDD+ may be overly complicated.

Partly due to the plantation of fast-growing monocultures, carbon sequestration and biodiversity are often in trade-off with one another when implementing AFOLU mitigation measures (Beer et al., 2003; Hirsch et al., 2011). While most research in the past took this perspective, the present study comes to the conclusion that this is not the case in the context of Costa Rica. The analysed policies favour a mix of species for carbon sequestration and target the enhancement of important regulating services. Jointly enhancing regulating services favours the reconciliation and common enhancement of the two putatively conflicting services of carbon sequestration and biodiversity. In part, it can be explained by the underpinning function of biodiversity for other ES. Ecosystems with intact biodiversity can provide multiple other ES that in turn enhance carbon sequestration. This indicates that a broader perspective, which not only considers interactions between the two ES at hand but rather focuses on the positive relationships among various additional ES, allows the simultaneous enhancement of carbon sequestration and biodiversity.

Similarly, as noted in the IPCC Assessment Report 5, water availability and carbon sequestration are generally reported to be in conflict (Smith et al., 2014). This may very well be the case for young forest plantations that consume large amounts of water. However, as the results in subchapter 4.8.1 “Freshwater & water regulation” indicate, increased biomass production does not necessarily reduce water services. A closer look is required to differentiate not only between the water use of trees of different ages but also for the array of trees regarding water flows in the local topography. On farms with AFS or SPS, where tree cover is not as high as on plantations or forests, water conservation can be higher than on farms without any trees. Recent findings by Ellison et al. (2017) support a differentiated perspective on the relationship of the two ES, reporting increased groundwater recharge through afforestation with an intermediate tree cover. Furthermore, the report increased dry season water flow with higher tree densities, which is more relevant in the tropics than annual water flow (ibid). In sum, this suggests a reconsideration of the general notion that a choice has to be made between enhancing water availability or carbon sequestration.

6.3 Recommendations for future research

Multiple limitations to this research have been described that result from uncertainties regarding impacts and interactions on the layer of affected ES. For this reason, further research is needed on ES impacts and interactions of AFOLU policies in general and for the case of Costa Rica’s land-use NAMAs and REDD+ implementation in particular. The list of ES interactions presented in the results is confined to services relevant to the situation in Costa Rica. Other ES may be relevant for AFOLU policies in a different geographical and political context, which still need to be examined for their potential interactions. For more detailed and possibly even quantitative knowledge on interactions between ES affected by AFOLU policies, further research is needed on more advanced cases (ex-post analyses) where more information is available on implementation practices and ES impacts.

A proposition by Bennett et al. (2009) suggests that "managing relationships among ecosystem services can strengthen ecosystem resilience, enhance the provision of multiple services, and help avoid catastrophic shifts in ecosystem service provision" (p. 1398). The identification of potential interactions between affected ES in an agroforestry context is the first step toward managing their relationship. Results presented here may promote understanding of their complex relationships. This opens doors to new research topics, specifically on how interaction of ES impacts can be optimised to exploit synergies and reduce trade-offs. Similarly, the identification of interactions among policy processes and outputs enables their optimisation. Once potential policy interactions are identified, this knowledge can be used to make corrections in the policy process. How such corrections can be made in practice by policy makers is a question that now requires the attention of scholars.

6.4 Lessons learnt & policy recommendations

The last section of this chapter provides recommendations for policy makers or consultants involved in the development of a REDD+ Strategy or a land-use. Many lessons and recommendations can easily be derived from the synergies and trade-offs presented in chapter 4. "Results". In the following, a list is given with more specific lessons learnt from the analysis in Costa Rica and resulting recommendations for officials and consultants involved in developing land-use policies. The suggestions can be used to sensitise policy formulation regarding potential interactions and integrate policies in the AFOLU sectors. They can serve to improve cooperation among involved actors and interinstitutional coordination for higher efficiency. Taking them into account can help increase the optimisation of interactions among policies and ES impacts and thus the policies' effectiveness.

- A favourable environment for policy coherence can be created through a strategic and integrated policy framework, outlining a desirable development pathway that addresses priorities and covers complementary policy options. It is helpful to highlight the importance of aligning individual (AFOLU) policies in order to maximise synergy effects between them and reduce trade-offs to a minimum. This way, the concept of policy coherence can be mainstreamed in the national policy arena.
- Thorough coordination between the individual policy processes and streamlined responsibilities set the ground for beneficial interactions. Coordination and collaboration in the early policy stages improves interactions among policy objectives, instruments, implementation practices. Ensuring consistency of policy outputs on all these layers enables an optimal exploitation of synergies and increases the chance for trade-offs to be revealed.
- During the policy process, a focus on exploiting synergies with other land-use policies is very important in order to increase the policies' effectiveness. Equally important are considerations of potential trade-offs and adverse effects, since their identification

empowers policy makers to reduce detrimental impacts on the policies' effectiveness. It can therefore be useful to develop a protocol that defaults a combined panel of scholars and policy makers to search for potential interactions with related policies already before concluding policy formulation.

- The creation of a central organ responsible for all climate change related policy processes can be very helpful for improved interinstitutional coordination and for streamlining related policy tasks. This enables the creation and exploitation of various synergies and facilitates the identification and reduction of trade-offs (meta-level synergy). Given the role of ES for climate change mitigation and adaptation, this organ may also hold responsibilities for ensuring consistent targeting of and impacts on relevant services.
- Prioritising and explicitly targeting certain ES, according to their interdependence and role for sustainable development in country, is an important step in their simultaneous enhancement. Explicit targeting facilitates and promotes including ES in policy (coherence) analyses to account for impacts on and interactions between affected ES. Prioritising bundles of services allows to reduce inherent trade-offs between ES that would be difficult or impossible to manage otherwise.
- Taking into account limitations to the institutional capacities in the country can be useful when choosing an appropriate level of policy integration. The integration of NAMAs and REDD+ is most suitable for high capacity countries, as it requires institutional and administrative coordination capacity and technical capacity. Opting for integrated approaches with a lack of technical capacity may lead to various undesirable interactions.
- Double counting of emission reductions on the national level is a very important potential adverse effect between AFOLU mitigation policies as explained in subchapter 4.5.2 "Inaccurate emission accounting". Formal integration of NAMAs and REDD+ with the adherence to common methods and safeguards, streamlined REL establishment and a joint registry and MRV system can significantly reduce the risk of double counting.
- The integration and synergistic implementation of AFOLU policies will likely require additional capacities for all involved governance levels and sectors. Therefore a national capacity-building strategy can contribute to integrate knowledge and streamline efforts. A "land-use competency strategy" may plan the combination and synthesis of relevant knowledge by different experts, which is disseminated both through central conferences and a network of trainers and specialised capacity building events for public and private actors on all governance and management levels.
- Financial instruments to increase the competitiveness of desired land-use types can be integrated to avoid conflicting incentives. Forestry and agroforestry can be promoted simultaneously, for instance, by including both land-use types in a national PES scheme.
- Certain policy instruments can be implemented synergistically by both REDD+ and NAMAs, such as awareness campaigns for the importance of trees and legal incentive to plant them. Other instruments can be implemented by one policy and contribute to the effectiveness of others, such as community fire control, reduced use of

agrochemicals and live fences. Yet other instruments implemented by one policy can complement instruments of others, such as reforesting degraded land and promoting AFS/SPS.

- Agroforestry and silvopasture systems are very potent instruments for AFOLU mitigation efforts in countries of Latin America and the Caribbean, simultaneously enabling various socioeconomic and ecological synergy effects. The benefits of such tree-based production systems can be increased by taking into account the prioritisation of ES in the choice of implementation practices.
- The management of interactions benefits from a focus on trade-offs and synergies specific to the national context. Considerations of risks and opportunities resulting from geographic, climatic or socio-political circumstances in the region provide high potential to increase policy effectiveness. A policy framework clarifying the national priorities in the light of regional circumstances can mainstream priorities into individual policies, which, in turn, mutually reinforce each other in that regard.

8. Appendix: Costa Rica

8.1 Focus ecosystem services

Synergies resulting from the clear and often explicit targeting of ES in Costa Rica should be understood within the national context, which exhibits a peculiarity regarding the role of ecosystems. The country's history of pioneering conservation efforts may be rooted in the extraordinary proportion of global biodiversity (5 percent) that can be found on the national territory, which only constitutes 0.03 percent of global land surface (PND). It may further be rooted in the population's strong awareness of the importance of ecosystems and their conservation, which was observed during this research and can also be deducted from the large body of environmental legislation and literature on the country's ES. The importance of ecosystems and the services they provide is consequently a part of the society. Economy and livelihoods largely depend on the provision of ES, which is common in developing countries (Vignola et al., 2009). This dependence and the people's awareness thereof has been made explicit in the large amount of policy objectives for the conservation of natural resources and directly targeting the enhancement of ES, a circumstance that strongly contributes to the dominance of potential ES synergies identified here. A large part of those synergies is also related to the strong focus on AFS and SPS in the analysed policies. Agroforestry practices foster high potential to create ecosystem service benefits in the Neotropical regions of Latin America and the Caribbean.

8.2 History of the national PES scheme

Costa Rica is one of the countries with the most experience in the governance of ES. The country's PPSA emerged from tax rebates to provide incentives for timber plantations. This incentive was broadened with the introduction of the Forest Credit Certificate, which saw different variants over the years. Important was the step to supporting conservation rather than timber production through the Forest Protection Certificate of 1995. With the creation of the PPSA, support shifted from the timber industry to the conservation of four specific ES. The Forest Law No.7575 of 1996 provides the basis to compensate landowners for maintaining watershed functions, biodiversity, carbon sequestration and scenic beauty. Funding was no longer sourced solely from tax money as beneficiaries signed up for voluntary payment. The PPSA evolved significantly until payments from certain beneficiaries became involuntary, including water service users such as hydroelectric power plants. Biodiversity services are financially covered by the Global Environment Facility, payments for carbon sequestration are collected through fuel tax revenues. In addition to many free riders among the water users, actors benefiting from scenic beauty are not included in the payments yet. To receive payments, landowners must have a licensed forester prepare a sustainable forest management plan. The first payment and the specific practices begin after the plan has been approved by the National Forestry Finance Fund (Fondo Nacional de Finaciamiento Forestal, FONAFIFO), subsequent payments require the verification of compliance by the forester, including sample auditing. (Pagiola, 2008)

8.3 Policy coherence as a REDD+ safeguard

A number of safeguards have been agreed upon that should be promoted when implementing REDD+ activities to reduce associated risks such as jeopardising forest ES other than climate regulation. The first safeguard requires that "actions complement or are consistent with the objectives of national forest programmes and relevant international conventions and agreements" (UNFCCC, 2011, p. 26). Costa Rica's National Forest Development Plan (Plan Nacional de Desarrollo Forestal) is such a programme that national REDD+ actions should be consistent with. Policy 3 of this plan mentions the promotion of agroforestry for the provision of ES and sustainable timber and non-timber forest products. This exact issue is taken up by the land-use NAMAs in Costa Rica, which is one way how the policies are linked in the institutional framework.

7. References

Angelsen, A. (2010). Policies for reduced deforestation and their impact on agricultural production. *Proceedings of the National Academy of Sciences*, *107*(46), 19639–19644. https://doi.org/10.1073/pnas.0912014107

Avelino, J., ten Hoopen, G. M., & DeClerck, F. A. J. (2011). Ecosystem Services from Agriculture and Agroforestry: Measurement and Payment. In B. Rapidel, F. A. J. DeClerck, J.-F. Le Coq, & J. Beer (Eds.) (1st ed., pp. 91–118). London: Earthscan.

Ayalew Ali, D., Deininger, K., & Goldstein, M. (2014). Environmental and gender impacts of land tenure regularization in Africa: Pilot evidence from Rwanda. *Journal of Development Economics*, *110*, 262–275. https://doi.org/10.1016/j.jdeveco.2013.12.009

Beer, J., Harvey, C. A., Ibrahim, M., Harmand, J., Somarriba, E., & Jiménez, F. (2003). Servicios ambientales de los sistemas agroforestales. *Agroforestería En Las Américas*, *10*(37–28). Retrieved from http://repositorio.bibliotecaorton.catie.ac.cr/handle/11554/6806

Bennett, E. M., Peterson, G. D., & Gordon, L. J. (2009). Understanding relationships among multiple ecosystem services. *Ecology Letters*, *12*(12), 1394–1404. https://doi.org/10.1111/j.1461-0248.2009.01387.x

Bustamante, M., Robledo-Abad, C., Harper, R., Mbow, C., Ravindranat, N. H., Sperling, F., … Smith, P. (2014). Co-benefits, trade-offs, barriers and policies for greenhouse gas mitigation in the agriculture, forestry and other land use (AFOLU) sector. *Global Change Biology*, *20*(10), 3270–3290. https://doi.org/10.1111/gcb.12591

Calvin, K. V., Beach, R., Gurgel, A., Labriet, M., & Loboguerrero Rodriguez, A. M. (2016). Agriculture, forestry, and other land-use emissions in Latin America. *Energy Economics*, *56*, 615–624. https://doi.org/10.1016/j.eneco.2015.03.020

Canadell, J. G., & Raupach, M. R. (2008). Managing Forests for Climate Change Mitigation. *Science*, *320*, 1456–1457. https://doi.org/10.1126/science.1155458

Chacón, M., Segura, J., Jenkins, A., Fallas, M., Obando, D., Villanueva, C., … Rosenstock, T. S. (2015). *Next steps of the Livestock NAMA in Costa Rica Synthesis of stakeholder consultations and rapid assessment of their current status*. Retrieved from https://cgspace.cgiar.org/rest/bitstreams/91287/retrieve

Climate Focus. (2016). *Double Counting in the Paris Agreement*. Retrieved from http://www.climatefocus.com/sites/default/files/20160105 -v.2.0 Double Counting and Paris Agreement FIN.pdf.pdf

Corbera, E., & Schroeder, H. (2011). Governing and implementing REDD+. *Environmental Science and Policy*, *14*(2), 89–99. https://doi.org/10.1016/j.envsci.2010.11.002

Costanza, R., D'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., … van den Belt, M. (1997). The value of the world's ecosystem services and natural capital. *Nature*, *387*(6630), 253–260. https://doi.org/10.1038/387253a0

Costenbader, J., Pritchard, L., Galt, H., & Stanley, L. (2013). *NAMAs and REDD+: Relationship and main issues for consideration - with a focus on Southeast Asia*. Eschborn. Retrieved from http://new.forestcarbonportal.com/documents/files/namasandredd.pdf

Daily, G. C., Ceballos, G., Pacheco, J., Suzán, G., & Sánchez-Azofeifa, A. (2003). Countryside Biogeography of Neotropical Mammals : Conservation Opportunities in Agricultural Landscapes of Costa Rica. *Conservation Biology*, *17*(6), 1814–1826.

DCC-MINAE. (2017). *Acciones de mitigación en el sector forestal: posibles dobles contabilidades y propuestas de solución*.

De Beenhouwer, M., Aerts, R., & Honnay, O. (2013). A global meta-analysis of the biodiversity and ecosystem service benefits of coffee and cacao agroforestry. *Agriculture, Ecosystems and Environment*, *175*, 1–7. https://doi.org/10.1016/j.agee.2013.05.003

de Clerck, F., Benjamin, T., Casanoves, F., Gutiérrez, I., Harvey, C. A., Sánchez, D., & Ibrahim, M. (2011). Agroforesteria en las Americas - Edición especial conservación de biodiversidad en sistemas agrícolas. *Agroforesteria En Las Americas*, (48), 1–167.

Dudley, N., & Stolton, S. (2003). *Running Pure: The importance of forest protected areas to drinking water*. World Bank / WWF Alliance for Forest Conservation and Sustainable Use.

Ellison, D., Morris, C. E., Locatelli, B., Sheil, D., Cohen, J., Murdiyarso, D., … Sullivan, C. A. (2017). Trees, forests and water: Cool insights for a hot world. *Global Environmental Change*, *43*, 51–61. https://doi.org/10.1016/j.gloenvcha.2017.01.002

FCPF, & UN-REDD Programme. (2015). *Joint FCPF/UN-REDD Programme Guidance Note for REDD+ Countries: Establishing and Strengthening Grievance Redress Mechanisms*. Washington DC. Retrieved from http://www.unredd.net/documents/global-programme-191/grievance-and-compliance-1455/national-grievance-mechanisms-3390/14201-joint-fcpfun-redd-guidance-note-for-redd-countries-establishing-and-strengthening-grievance-redress-mechanisms-1.html?path=global-p

Feoli, M. (2013). *Best Practices in Institutional Arrangements NAMA NAMA*. Retrieved from https://unfccc.int/files/focus/mitigation/application/pdf/nama_coffee-presentation-feoli.pdf

García-Rangel, S., Walcott, J., de Lamo, X., Epple, C., Miles, L., Kapos, V., … Vega-Araya, E. (2017). *Beneficios múltiples de REDD+ en Costa Rica: análisis espaciales para apoyar la toma de decisiones*. Cambridge, UK.

Gehring, T., & Oberthür, S. (2009). The Causal Mechanisms of Interaction between International Institutions. *European Journal of International Relations*, *15*(1), 125–156. https://doi.org/10.1177/1354066108100055

Global Environment Facility. (2005). *Project Executive Summary: Mainstreaming Market-Based Instruments for Environmental Management*. Retrieved from http://documents.worldbank.org/curated/en/412941468032708713/pdf/368490CR0P098810Summary0WP01PUBLIC1.pdf

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The Qualitative Report*, *8*(4), 597–606. Retrieved from http://www.nova.edu/ssss/QR/QR8-4/golafshani.pdf

Gullison, R. E., Frumhoff, P. C., Canadell, J. G., Field, C. B., Nepstad, D. C., Hayhoe, K., … Nobre, C. (2007). Tropical Forests and Climate Policy. *Science*, (316), 985–986. https://doi.org/10.1126/science.1136163

Harvey, C. A., Chac, M., Donatti, C. I., Garen, E., Hannah, L., Andrade, A., … Wollenberg, E. (2014). Climate-Smart Landscapes: Opportunities and Challenges for Integrating Adaptation and Mitigation in Tropical Agriculture. *Conservation Letters*, *7*(April), 77–90. https://doi.org/10.1111/conl.12066

Harvey, C. A., Villanueva, C., Esquivel, H., Gómez, R., Ibrahim, M., Lopez, M., … Sinclair, F. L. (2011). Conservation value of dispersed tree cover threatened by pasture management. *Forest Ecology and Management*, *261*(10), 1664–1674. https://doi.org/10.1016/j.foreco.2010.11.004

Hirsch, P. D., Adams, W. M., Brosius, J. P., Zia, A., Bariola, N., & Dammert, J. L. (2011). Acknowledging

Conservation Trade-Offs and Embracing Complexity. *Conservation Biology*, *25*(2), 259–264. https://doi.org/10.1111/j.1523-1739.2010.01608.x

Jackson, R. B., Jobbágy, E. G., Avissar, R., Baidya Roy, S., Barrett, D. J., Cook, C. W., … Murray, B. C. (2005). Trading Water for Carbon with Biological Carbon Sequestration. *Science*, *310*(DECEMBER), 1944–1948.

Jones, T. (2002). Policy Coherence, Global Environmental Governance, and Poverty Reduction. *International Environmental Agreements: Politics, Law and Economics*, *2*(4), 389–401. https://doi.org/10.1023/A:1021319804455

Jordan, A., & Lenschow, A. (2010). Policy paper environmental policy integration: A state of the art review. *Environmental Policy and Governance*, *20*(3), 147–158. https://doi.org/10.1002/eet.539

Jump, A. S., & Peñuelas, J. (2005). Running to stand still: adaptation and the response of plants to rapid climate change. *Ecology Letters*, *8*, 1010–1020. https://doi.org/10.1111/j.1461-0248.2005.00796.x

Kalaba, F. K., Quinn, C. H., & Dougill, A. J. (2014). Policy coherence and interplay between Zambia's forest, energy, agricultural and climate change policies and multilateral environmental agreements. *International Environmental Agreements: Politics, Law and Economics*, *14*(2), 181–198. https://doi.org/10.1007/s10784-013-9236-z

Kosoy, N., & Corbera, E. (2010). Payments for ecosystem services as commodity fetishism. *Ecological Economics*, *69*(6), 1228–1236. https://doi.org/10.1016/j.ecolecon.2009.11.002

Lambin, E. F., Meyfroidt, P., Rueda, X., Blackman, A., Börner, J., Cerutti, P. O., … Wunder, S. (2014). Effectiveness and synergies of policy instruments for land use governance in tropical regions. *Global Environmental Change*, *28*(1), 129–140. https://doi.org/10.1016/j.gloenvcha.2014.06.007

Leip, A., Carmona-Garcia, G., & Rossi, S. (2017). *Mitigation measures in the Agriculture, Forestry, and Other Land Use (AFOLU) sector. Quantifying mitigation effects at the farm level and in national greenhouse gas inventories*. Luxembourg. https://doi.org/10.2760/51052

Limburg, K. E., O'Neill, R. V., Costanza, R., & Farber, S. (2002). Complex systems and valuation. *Ecological Economics*, *41*(3), 409–420. https://doi.org/10.1016/S0921-8009(02)00090-3

Luttrell, C., Loft, L., Gebara, M. F., Kweka, D., Brockhaus, M., Angelsen, A., & Sunderlin, W. D. (2013). Who Should Benefit from REDD+? Rationales and Realities. *Ecology and Society*, *18*(4). Retrieved from http://www.cifor.org/publications/pdf_files/articles/ALuttrell1301.pdf

Mace, G., Masundire, H., Baillie, J., Ricketts, T., Brooks, T., Hoffmann, M., … Williams, P. (2005). Biodiversity. In G. Ceballos, S. Lavorel, G. Orians, & S. Pacala (Eds.), *Millenium Ecosystem Assessment: Current State & Trends Assessment* (pp. 77–122). Washington DC: Island Press.

MAG, CORFOGA, CATIE, & UNEP. (2015). *NAMA Ganadería*. Retrieved from http://www.mag.go.cr/bibliotecavirtual/a00368.pdf

Makkonen, M., Huttunen, S., Primmer, E., Repo, A., & Hildén, M. (2015). Policy coherence in climate change mitigation: An ecosystem service approach to forests as carbon sinks and bioenergy sources. *Forest Policy and Economics*, *50*, 153–162. https://doi.org/10.1016/j.forpol.2014.09.003

Maniatis, D., Paz, C., Enters, T., DeVit, C., & Eggerts, E. (2017). *REDD+ ACADEMY Edition Two (2017) LEARNING JOURNAL Module 2: Understanding REDD+ and the UNFCCC*. Retrieved from http://www.unredd.net/documents/global-programme-191/redd-academy-3509/redd-academy-learning-journals/english/14971-redd-academy-learning-journal-module-2-

understanding-redd-and-the-unfccc.html

Michaelowa, A., Wemaere, M., Honegger, M., Hoch, S., & Matsuo, T. (2015). *Linking CDM PoAs and NAMAs - Legal and Technical Challenges and Proposed Design Options*.

Mickwitz, P., Aix, F., Beck, S., Carss, D., Ferrand, N., Görg, C., … Van Bommel, S. (2010). *Climate policy integration, coherence and governance*. *Peer Report* (Vol. 2).

MIDEPLAN, C. R.-M. de P. N. y P. E. (2014). *Plan Nacional de Desarrollo 2015-2018 "Alberto Canas Escalante."* San José, CR. Retrieved from www.mideplan.go.cr

Millennium Ecosystem Assessment. (2005). *Ecosystems and human well-being: synthesis*. Washington, D.C.: Island Press. https://doi.org/10.1196/annals.1439.003

MINAE. (2014). *Costa Rica - Livestock NAMA Concept*. Retrieved from http://www.lowemissiondevelopment.org/lecbp/docs/NAMA_Concept_Livestock_Costa_Rica_Nov_2014.pdf

MINAE. (2015). *Estrategia Nacional REDD+ Costa Rica*. Retrieved from https://www.forestcarbonpartnership.org/sites/fcp/files/2015/October/8-Costa Rica Borrador de la Estrategia Nacional REDD%2BSpanish v 30 Sept.pdf

MINAE, DCC, AECID, & EPYPSA. (2012). *Plan de acción de la estrategia nacional de cambio climático*. San José, CR. Retrieved from http://www.cambioclimaticocr.com/biblioteca-virtual/doc_download/214-plan-de-accion-estrategia-nacional-cambio-climatico

Minang, P., Bernard, F., van Noordwijk, M., & Kahurani, E. (2011). *Agroforestry in REDD+: Opportunities and Challenges*. *ASB Policy Brief No. 26*. Nairobi, Kenya. Retrieved from http://www.asb.cgiar.org/PDFwebdocs/ASB_PB26.pdf

Mohammed, E. Y. (2011). *Pro-poor benefit distribution in REDD+: who gets what and why does it matter? REDD Working Paper*. IIED, London. Retrieved from http://theredddesk.org/sites/default/files/resources/pdf/2012/16508iied.pdf

Munang, R., Thiaw, I., Alverson, K., Liu, J., & Han, Z. (2013). The role of ecosystem services in climate change adaptation and disaster risk reduction. *Current Opinion in Environmental Sustainability*, *5*(1), 47–52. https://doi.org/10.1016/j.cosust.2013.02.002

Nieters, A., Grabs, J., Jimenez, G., & Alpizar, W. (2010). *NAMA Café Costa Rica –A Tool for Low-Carbon Development*. Retrieved from http://www.nama-facility.org/fileadmin/user_upload/Factsheet_-_Implementation_of_the_NAMA_Support_Project_-_Low_Carbon_Coffee_Costa_Rica.pdf

Nilsson, M., & Persson, A. (2003). Framework for analysing environmental policy integration. *Journal of Environmental Policy & Planning*, *5*(4), 333–359. https://doi.org/10.1080/1523908032000171648

Nilsson, M., Zamparutti, T., Petersen, J. E., Nykvist, B., Rudberg, P., & Mcguinn, J. (2012). Understanding Policy Coherence: Analytical Framework and Examples of Sector-Environment Policy Interactions in the EU. *Environmental Policy and Governance*, *22*(6), 395–423. https://doi.org/10.1002/eet.1589

Noponen, M. R. A., Haggar, J. P., Edwards-Jones, G., & Healey, J. R. (2013). Intensification of coffee systems can increase the effectiveness of REDD mechanisms. *Agricultural Systems*, *119*, 1–9. https://doi.org/10.1016/j.agsy.2013.03.006

Oikonomou, V., & Jepma, C. J. (2008). A framework on interactions of climate and energy policy instruments. *Mitigation and Adaptation Strategies for Global Change*, *13*(2), 131–156.

https://doi.org/10.1007/s11027-007-9082-9

Olander, L. P., Gibbs, H. K., Steininger, M., Swenson, J. J., & Murray, B. C. (2008). Reference scenarios for deforestation and forest degradation in support of REDD: a review of data and methods. *Environmental Research Letters*, *3*(2), 1–11. https://doi.org/10.1088/1748-9326/3/2/025011

Olsson, P., Gunderson, L. H., Carpenter, S. R., Ryan, P., Lebel, L., Folke, C., & Holling, C. S. (2006). Shooting the Rapids: Navigating Transitions to Adaptive Governance of Social-Ecological Systems. *Ecology and Society*, *11*(1). Retrieved from https://www.ecologyandsociety.org/vol11/iss1/art18/main.html

Ostrom, E. (2007). A diagnostic approach for going beyond panaceas. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(39), 15181–7. https://doi.org/10.1073/pnas.0702288104

Pacheco, A. G. F. (2017). *Climate Change Governance: the case of land-use based emissions MRV systems in Central America and the Dominican Republic*. CATIE. Retrieved from https://www.researchgate.net/publication/318725206_Climate_Change_Governance_the_case_of_land-use_based_emissions_MRV_systems_in_Central_America_and_the_Dominican_Republic

Pagiola, S. (2008). Payments for environmental services in Costa Rica. *Ecological Economics*, *65*(4), 712–724. https://doi.org/10.1016/j.ecolecon.2007.07.033

Paustian, K., Ravindranath, N. H., van Amstel, A., Gytarsky, M., Kurz, W. A., Ogle, S., … Somogyi, Z. (2006). Introduction. In *IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4: Agriculture, Forestry and Other Land Use* (pp. 11–29). Cambridge, UK and New York, NY, USA: Cambridge University Press. https://doi.org/10.1111/j.1440-1843.2006.00937_1.x

Pedroni, L., Espejo, A., & Villegas, J. F. (2015). *Nivel de referencia de emisiones y absorciones forestales de Costa Rica ante el Fondo de Carbono de FCPF: metodología y resultados*.

Perfecto, I., Vandermeer, J. H., Bautista, G. L., Nuñez, G. I., Greenberg, R., Bichier, P., & Langridge, S. (2004). Greater predation in shaded coffee farms: the role of resident neotropical birds. *Ecology*, *85*(10), 2677–2681.

Phelps, J., Webb, E. L., & Agrawal, A. (2010). Does REDD + Threaten to Recentralize Forest Governance? *Science*, *328*(April), 312–313. https://doi.org/10.1126/science.1187774

Power, A. G. (2010). Ecosystem services and agriculture: tradeoffs and synergies. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *365*(1554), 2959–2971. https://doi.org/10.1098/rstb.2010.0143

Pramova, E., Locatelli, B., Brockhaus, M., & Fohlmeister, S. (2012). Ecosystem services in the National Adaptation Programmes of Action. *Climate Policy*, *12*(4), 393–409. https://doi.org/10.1080/14693062.2011.647848

Rodríguez, J. P., Beard, T. D., Bennett, E. M., Cumming, G. S., Cork, S. J., Agard, J., … Peterson, G. D. (2006). Trade-offs across Space , Time , and Ecosystem Services, *11*(1).

Rojas, A. Q., Schirmeier, N., Jimenez, G., Musmanni, S., Alexia Quirós Rojas, Nora Schirmeier, Gustavo Jimenez, S. M., & Vargas, V. (2016). *NAMA Café Costa Rica – MRV System of the Carbon Footprint in Green Coffee Production and Processing*. Retrieved from http://namacafe.org/sites/default/files/content/factsheet_mrv_en_2016-10.pdf

Rosenzweig, C., Iglesias, A., Yang, X. B., Epstein, P. R., & Chivian, E. (2001). Climate change and extreme weather events. *Global Change and Human Health*, *2*(2), 90–104.

Ryan, D. (2017). *Factores que afectan la implementación de las Contribuciones Nacionales en el sector agropecuario y forestal en América Latina*. Retrieved from https://cdkn.org/wp-content/uploads/2017/05/DT_FactoresNDCs-2.pdf

Schneider, L., Kollmuss, A., & Lazarus, M. (2014). *Addressing the risk of double counting emission reductions under the UNFCCC*. *Stockholm Environment Institute*. https://doi.org/10.1007/s10584-015-1398-y

Schroth, G., & McNeely, J. A. (2011). Biodiversity Conservation, Ecosystem Services and Livelihoods in Tropical Landscapes: Towards a Common Agenda. *Environmental Management*, *48*(2), 229–236. https://doi.org/10.1007/s00267-011-9708-2

Sharma, S., & Desgain, D. (2013). *Understanding the Concept of Nationally Appropriate Mitigation Action*. Retrieved from http://orbit.dtu.dk/files/57802310/understanding_the_concept.pdf

Shvidenko, A., Barber, C. V., Persson, R., Gonzalez, P., Hassan, R., Lakyda, P., … Scholes, B. (2005). Forest and Woodland Systems. In M. de los Angeles & C. Sastry (Eds.), *Millenium Ecosystem Assessment: Current State & Trends Assessment* (pp. 585–621). w: Island Press.

Smith, P., Bustamante, M., Ahammad, H., Clark, H., Dong, H., Elsiddig, E. A., … Tubiello, F. N. (2014). Agriculture, Forestry and Other Land Use (AFOLU). In O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, … J. C. Minx (Eds.), *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 811–922). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Tubiello, F. N., Cóndor-Golec, R. D., Salvatore, M., Piersante, A., Federici, S., Ferrara, A., … Prosperi, P. (2015). *Estimating Greenhouse Gas Emissions in Agriculture*. Rome: FAO. Retrieved from http://www.fao.org/3/a-i4260e.pdf

van Noordwijk, M., Agus, F., Dewi, S., & Purnomo, H. (2014). Reducing emissions from land use in Indonesia: Motivation, policy instruments and expected funding streams. *Mitigation and Adaptation Strategies for Global Change*, *19*(6), 677–692. https://doi.org/10.1007/s11027-013-9502-y

Verschuren, P., & Doorewaard, H. (2010). *Designing a Research Project* (2nd ed.). The Hague: Eleven International Publishing.

Vignola, R., Locatelli, B., Martinez, C., & Imbach, P. (2009). Ecosystem-based adaptation to climate change : what role for policy-makers , society and scientists ? *Mitigation and Adaptation Strategies for Global Change*, *14*(8), 691–696. https://doi.org/10.1007/s11027-009-9193-6

Vörösmarty, C. J., Lévque, C., Revenga, C., Bos, R., Caudill, C., Chilton, J., … Reidy, C. A. (2005). Fresh water. In F. Rijsberman, R. Costanza, & P. Jacobi (Eds.), *Millenium Ecosystem Assessment: Current State & Trends Assessment* (pp. 165–207). Washington DC: Island Press.

World Bank, CIAT, & CATIE. (2015). *Climate-Smart Agriculture in Costa Rica. CSA Country Profiles for Latin America Series. 2nd. ed.* Washington DC.