Institutional prospects and challenges in the governance of food security and biodiversity:

A case study in southwestern Ethiopia

Doctoral thesis by Tolera Senbeto Jiren

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Dedication

This dissertation is dedicated to the memory of my beloved Mom, **Sufe Gutema Aga**, who passed away in the midst of this study, February 4, 2017.

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Preface

This dissertation is presented as a series of manuscripts based on empirical research carried out in southwestern Ethiopia. Chapter I provides a general overview of the dissertation, including the overarching goal and specific aims, a summary of all included manuscripts, a synthesis of the results on governance properties that facilitate achieving individual as well as integrated goals of food security and biodiversity conservation in multi-level governance context, and finally recommendation for how to improve integrated governance of food security and biodiversity conservation. Beyond Chapter I, the manuscripts included in this dissertation (Chapters II-VI) are divided into three sections (Sections A, B, and C). Section A *(Governance of agricultural land use)* investigates how the globally widely, often theoretically discussed food security discourses (Chapters II) and land use frameworks (Chapters III) unfold at the local context and its influence to food security and biodiversity conservation. Under section B (*Governance structures and processes*), I focus on structural governance dimension (Chapter IV) and governance process dimension (Chapter V) to identify challenges that influence achievement of individual as well as integrated goals of food security and biodiversity conservation in a multi-level governance context. Finally, Section C (Futures pathways) draws on a participatory scenario planning process to sketch out future development trajectories of the study area, with a focus on food security and biodiversity conservation. With the exception of Chapter I, all manuscripts are either published (chapters III and IV), under review (Chapter II and VI), in preparation (Chapter V) in an international scientific journals (peer reviewed). I, the author of this dissertation, conducted the majority of the research presented in this dissertation and am the lead author of all the manuscripts presented in this dissertation. A reference to the journal each manuscript is submitted to and the contributing co-authors is presented on the title page of each chapter. The chapters are designed to be stand-alone articles; therefore stylistic differences and some repetition are possible among the chapters. The content of each chapter is the same as in the published journal article with figure and table legends adapted to this dissertation. The style used for citing literature, in the text and for the references at the end of each chapter, represents the formatting requirements of the respective journal or book.

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Abstract

Ensuring food security and halting biodiversity loss are two of the most pressing global sustainability challenges. Traditionally food security and biodiversity conservation were treated as mutually exclusive goals, and as a result, discourses and approaches were developed separately around each of these goals. Recently, however, sustainability science increasingly recognizes the close interdependence of food security and biodiversity and hence, pays greater emphasis to the need for integration of the two goals. Navigating pathways to ensure the successful integration of the two goals is, therefore, an important requirement. Attempts to identify pathways toward such integration have been dominated with a biophysical-technical focus that provides technical solutions to the integration of food security and biodiversity conservation. To this end, different food production techniques, and agricultural land use strategies have been widely considered as a solution to the food security-biodiversity nexus. While much scholarly attention has been given to the biophysical-technical dimensions, the social-political dimension, including equity, governance, and empowerment received little to no attention. By focusing on the poorly investigated social-political dimension, this dissertation aimed to identify governance properties that facilitate and impede the integration of food security and biodiversity conservation through an empirical case study conducted in a multi-level governance setting of southwestern Ethiopia.

To address the overarching goal of this dissertation, first I examined how the existing widely discussed food security approaches and agricultural land use framework, land sparing versus land sharing unfold in the local context of southwestern Ethiopia. The finding in this dissertation indicated that the existing global framing of food security approaches as well as frameworks around agricultural land use has limited applicability in on-the-ground realities mainly because landscapes are complex systems that consist of stakeholders with multiple and (often) conflicting interests. This was evident from the finding that, unlike the binary framing of agricultural land use as land sparing and land sharing, local land use preference was not a matter of ‘either/or’, but instead involved mixed features exhibiting properties of both land sparing and land sharing. Moreover, in addition to the biophysical factors embedded in the existing food security approaches and land use frameworks, stakeholders preference involved social factors such as the compatibility of land use strategy with local values and traditions, which are mainly unaccounted in the existing global frameworks. Findings in his dissertation revealed that the existing reductionist analytical framings to the issues of food security and

biodiversity conservation seldom address the complexity inherent within and between food security and biodiversity conservation sectors.

Second, this dissertation identified governance structural and process related challenges that influence individual as well as integrated achievements of food security and biodiversity conservation goals. The result of the study showed that the governance of food security and biodiversity conservation was characterized by a strongly hierarchical system with mainly linear vertical linkages, lacking horizontal linkages between stakeholders that would transcend administrative boundaries. This type of governance structure, where stakeholders interaction is restricted to administrative boundaries could not fit with the nature of food security and biodiversity conservation because the two goals are complex in their own involving sub-systems transcending different policy sectors and administrative boundaries. Furthermore, with regard to the governance process, three key and interdependent categories of governance process challenges namely, institutional misfit, the problem of interplay, and policy incoherence influenced the achievement of individual and integrated goals of food security and were identified. Given the interdependence of these governance challenges, coupled with the complexity inherent in the food security and biodiversity conservation, attempts to achieve the dual goals thus needs an integrative, flexible and adaptive governance system

Third, to understand how food security and biodiversity conservation unfold in the future, I explored future development trajectories for southwestern Ethiopia. Iterative scenario planning process produced four plausible future scenarios that distinctly differed with regard to dominating land use strategies and crops grown, actor constellations and governance mechanisms, and outcomes for food security and biodiversity conservation. Three out of the four scenarios focused on increasing economic gains through intensive and commercial agricultural production. The agricultural intensification and commercialization may increase food availability and income gains, but negatively affect food security through neglecting other dimensions such as dietary diversity, social justice and stability of supply. It also affects biodiversity conservation by causing habitat loss, land degradation, and water pollution, biodiversity loss. In contrast, one scenario involved features that are widely considered as beneficial to food security and biodiversity conservation, such as agroecological production, diversification practices, and increased social-ecological resilience. In smallholder landscapes such as the one studied here, such a pathway that promises benefits for both food security and biodiversity conservation may need to be given greater emphasis.

In order to ensure the integration of food security and biodiversity conservation, recognizing their interdependence and addressing the challenges in a way that fits with the local dynamics is essential. In addition, addressing the food security-biodiversity nexus requires a holistic analytical lens that enables proper identification of system properties that benefit food security and biodiversity conservation. Moreover, this dissertation indicated that there is a clear need to pay attention to the governance structure that accommodates the diversity of perspectives, enable participation and strong coordination across geographical boundaries, policy domains and governance levels.

Finally, this dissertation revealed opportunities to integrate food security and biodiversity through the pro-active management of social-ecological interactions that produce a win-win outcome. The win-win outcome could be achieved in a system that involve properties such as diversification and modern agroecological techniques, smallholders empowerment, emphasize adaptive governance of social-ecological systems, value local knowledge, culture and traditions, and ensure smallholders participation. While such diversification and agroecological practices may lack the rapid economic development that is inherent to the conventional intensification, it essentially create a system that is more resilient to environmental and economic shocks, thereby providing a more sustainable long-term benefit.

Chapter I

Chapter I

Institutional prospects and challenges in the governance of food security and biodiversity:

A case study in southwestern Ethiopia

Tolera Senbeto Jiren

Landscape in one of the study kebeles, Gido Bere

"Food production in Ethiopia is like a blind roller-coaster ride. You never know what will happen the next moment or whether it will take you up or down." Glopolis

Introduction

Ensuring food security and biodiversity conservation are two of the most pressing global sustainability challenges. In the face of increasing pressures such as from human population growth, climate change and natural disaster, the urgency of achieving these two sustainability goals has become more crucial than ever (Chappell and LaValle 2011). The fact that both food security and biodiversity loss are worsening, however, indicates that this is a challenging undertaking. Even though food production has doubled in the past four decades (Foley et al. 2011), food insecurity and malnutrition have also increased (McLaughlin 2011), currently making one in nine people food insecure (FAO 2018). Similarly, biodiversity loss has been rapidly increasing, with the current rates of species extinction being 1000 times higher than natural background rates (Pimm et al. 2014).

A key feature of food security and biodiversity conservation is that they are highly interconnected and, especially in smallholder-dominated agricultural landscape, have evolved as part of the same social-ecological system (Chappel and LaValle 2011; Tscharntke et al. 2012). Interventions targeted at achieving either goal could therefore reinforce or impediment the success of the other goal (Fischer et al 2014; Wittman et al 2016). For example, while agricultural production is a key factor to ensure sufficient food supply, it is also a major threat to biodiversity conservation (Chappell and LaValle 2009; Godfray et al. 2010; Wittman et al 2016). Similarly, strict biodiversity conservation practices such as fortress conservation can threaten the local food security (Naughton-Treves et al 2005; Fischer et al 2017). Given their interdependence, whether and how the two goals can be achieved simultaneously remains a central, unresolved question to the field of sustainability.

Conventionally, food security and biodiversity conservation have been treated as mutually exclusive goals, and a vast majority of interventions are directed toward achieving each goal separately (Sunderland 2011; Tscharntke et al. 2012). As awareness of their interdependence is growing, however, the need for integrating the two goals is beginning to be recognized (Brussaard et al. 2010; Godfrey 2012) and current sustainability science increasingly attempts to identify pathways toward such integration (Chappell and LaVella 2009; Tscharntke et al. 2012; Collier et al. 2018).

The technical solutions and the biophysical-technical context continue to dominate both practice and academic debates around the integration of food security and biodiversity

conservation (Glamann et al. 2015). The problem of food security and biodiversity is most commonly viewed through the agricultural production lens — i.e. the idea that food production is the key impediment to ensure food security and biodiversity conservation outcomes (Wittman et al. 2016; Collier et al. 2018). The focus is also on technical solutions that can be generalized across various systems (Collier et al. 2018). Such framing has produced different food production approaches, e.g. agricultural intensification (Loos et al. 2014), and agricultural land use framework, e.g. the land sparing and land sharing framework (Green et al. 2005), as a means to improve food security and biodiversity conservation (Fischer et al. 2008). However, these framing around food security and biodiversity conservation are largely partial in (their) scope—e.g. food production approaches address the food availability aspect of food security while other components such as distributional and procedural justice are neglected (Fischer et al. 2014; Wittman et al. 2016) and lack the necessary contextualization to landscape-scale complexity (Chavez-Tafur et al. 2014; Habel et al. 2015).

An emerging framing of the food security and biodiversity challenge, for example, focuses on social-political aspects (see Glamann et al. 2015) and searches for non-technical solutions. Here, much more attention is paid to understanding the influence of social and political factors on food security and biodiversity conservation, including the governance system, power relations, human capital, and social justice (Glamann et al. 2015; Collier et al. 2018). Governance is a key component of social-ecological systems and influences sustainability outcomes in both ecological (e.g. biodiversity) and social (e.g. food security) domains. As conventional and existing academic framings around food security and biodiversity conservation dominated with a biophysical-technical focus, major governance components have received little to no attention (Kremen et al. 2015). This dissertation focuses on the poorly investigated governance dimension of food security and biodiversity conservation. It aims to identify governance system properties that facilitate or impede food security and biodiversity conservation in a multi-level governance setting of southwestern Ethiopia. In the following sections, I introduce the agricultural and the governance system as an interface between food security and biodiversity conservation.

Agricultural land use as an interface of food security and biodiversity conservation

From early development of civilization until now, agriculture in general and crop farming in particular has been the primary source of livelihood to millions of smallholder farmers. It helps not only the poor to overcome critical livelihood challenges, but it is also a backbone to the

growth of many developing, agriculture-based national economies (FAO 2012). Agricultural areas, and especially those smallholder agricultures (Scherr and McNeely 2007), can also harbor a rich biodiversity with high intrinsic and instrumental values (Thrup 2000). Agricultural land use is thus a critical interface to ensure both food security and the conservation of valuable biodiversity. Modern human modification of agricultural land use, often characterized by farmland expansion and agricultural intensification (Brussaard et al. 2010), fundamentally changed the composition of traditional farmland (Thrup 2000). It had beneficial outcomes, e.g. increased food production, but also caused severe social and ecological impacts, e.g. soil degradation, pollution, habitat loss, and biodiversity decline (Foley et al. 2011; McLaughlin 2011). Given multiple competing demands on agricultural land (use), it become imperative to find ways that integrate and benefit the goals of food security and biodiversity conservation (Godfray et al. 2010). The relation of agricultural land to food security and biodiversity conservation is probably most famously captured by the land use framework of land sparing versus land sharing (Green et al. 2005; Fischer et al. 2008). Here, land sparing strategy posits the spatial segregation of land between agricultural land uses from biodiversity conservation area (Green et al. 2005). This strategy aims to achieve food security through agricultural intensification, optimizing yield output with the use of inorganic fertilizer, agrochemicals, irrigation and mechanization (Loos et al. 2014). Biodiversity conservation is attained in protected areas of land spared from agricultural production (Balmford et al. 2005; Fischer et al. 2008). Land sharing, in contrast, asserts the spatial integration of food production and biodiversity conservation on the same land (Fischer et al. 2008), often through the application of ecofriendly agricultural production (Green et al. 2005; Phalan et al. 2011).

It is common practice that agricultural land use is part of both food security and biodiversity conservation efforts, but the scholarly framing around the agricultural land use has practical limitations. For instance, the land sparing and land sharing framework provides a simple binary choice, which may not be feasible in reality because the on-ground choice of strategy depends on multiple factors such as biophysical conditions of the landscape (e.g. topography and species richness) and social-cultural aspects often related to the governance context (e.g. diversity of interests and stakeholder preferences, land use arrangements and other factors) (Fischer et al. 2008; Chavez-Tafur et al. 2014; Kremen 2015). While debate is ongoing among scientists and policy makers regarding which option –land sparing or land sharing reconciles between food security and biodiversity conservation, it (the debate) is often theoretical, ignore importance of local complexities, and missed important issues including governance aspects (Habel et al.

2015; Kremen 2015). Understanding the governance aspects of such land use strategies at a local scale, however, is essential because improvements to policy and practice can only be made in relation to the complexity experienced at the local (landscape) scale.

Collaborative governance of food security and biodiversity conservation

'Governance' may have different meanings in different contexts, and there is no coherent conceptualization of governance in associated research fields. In this dissertation, governance is conceptualized, as opposed to the narrower definition of government, "to cover the whole range of institutions and relationships involved in the process of governing" (Pierre and Peters 2000, 1). This conceptualization recognizes the structural dimension that reflects patterns of stakeholder interactions across governance sectors and levels (Adger et al. 2005; Folke et al. 2016; Bodin 2017), but also the process dimension that indicates the procedures for setting policy, plans and strategies to achieve the intended goals of food security and biodiversity conservation (Young 2002; Visseren-Hamakers 2015). Institutions are a center piece of governance research, and include the formal and informal rules, regulations, and practices that set patterns of interactions between actors and regulate human behavior in governing food security and biodiversity conservation (Ostrom 1990; North 1990). The issue of scale emerges as an important subject in this dissertation and implies both spatial scales (e.g. global versus landscape scale; Cash et al 2006) as well as temporal scale (e.g. existing and future time frame; Gibson 2000). An important framework to this dissertation is also the multi-level governance (MLG) concept, which offers an analytical lens to capture the spatial distinctions among institutions on different levels putting special emphasis on the interlinkages and dynamics between those (Stephenson 2013, 817; Jager 2016).

Integrated governance of food security and biodiversity conservation constitutes a great challenge, not only because of the complexity arising from their interdependence (Berkes et al. 2003; Folke 2016), but also due to each individual sector's inherent complexity and multidimensionality. Both food security and biodiversity conservation are influenced by multiple biophysical and social-economic drivers, involve multiple other domains (e.g. agriculture, health and economy) and transcend multiple spatial scales (Chappel and LaValle 2011). Each sector is characterized by a multitude of stakeholder interests and a plurality of worldviews, e.g. neoliberal versus food sovereignty positions within the food security sector (Koc et al. 2013). Although such complexity has been recognized, existing governance literature is generally limited to describing the general qualities of governance structures and

processes related to addressing food security and biodiversity conservation (separately), while empirical studies that specifically assess how the governance system influences the integrated governance of food security and biodiversity are critically missing (Candel 2014).

A major focus of social-ecological systems governance literature outlines the desired qualities of governance systems. Such key governance features include the participation of multiple government and non-government stakeholders (Folke et al. 2005), the interaction of stakeholders across geographical boundaries, policy sectors and governance levels (Koontz et al. 2004; Folke et al. 2005; Bodin and Crona 2009), and a matching fit between the governance system and the corresponding social-ecological system (Paavola et al 2009). These properties can enhance effective communication, and allow for a diversity of perspectives, knowledge and innovation, effective learning, and collective action that improves outcomes for food security and biodiversity conservation (Folke et al. 2005; Bodin and Crona 2009). Notably, such governance properties are often embodied in the notion of collaborative governance (Ansell and Gash 2007; Ostrom 2007). In this dissertation, I relied on Emerson et al.'s (2012) definition of collaborative governance as the *"structures and processes of public policy decision making and management that engage people constructively across the boundaries of public agencies, levels of government, and/or the public, private and civic spheres in order to carry out a public purpose that could not otherwise be accomplished".* A related concept to collaborative governance is polycentric governance, where multiple stakeholders interact spanning vertically across political organizations and horizontally across public and private sectors whose boundaries are not mutually exclusive but instead overlap geographically (Ostrom 2010; Koontz et al. 2015). Collaborative and polycentric governance shares multiple characteristics which strengthen adaptive institutions and adaptive governance that foster sustainability outcome (Koontz et al. 2015).

Given the complexity and interdependence of food security and biodiversity, qualities of collaborative governance such as an inclusiveness and plurality of stakeholders, flexibility, and stakeholder interactions that transcend sectors, geographical and political boundaries all are important features that could help achieve the dual goal of food security and biodiversity conservation (Ansell and Gash 2007; Bodin et al. 2017). Such governance could accommodate a diversity of interests, foster the proper understanding of problems, encourage innovation, and promote collective action towards food security and biodiversity conservation (Emerson et al 2012). However, collaborative governance is not a panacea and may lead to adversary effects

such as problems of groupthink, and the manipulation of collaboration to advance the interests of powerful stakeholders (Ansell and Gash 2007). Its effectiveness is thus largely dependent on stakeholder motives, the collaborative network structure, and the capacity of stakeholders to address the problem of food security and biodiversity conservation (Bodin 2017). These are issues that are addressed by this dissertation particularly through investigating stakeholders interaction and challenges in the governance of food security and biodiversity conservation at a multi-level governance context.

Food security and biodiversity conservation in Ethiopia

Ethiopia shares multiple social-ecological system properties of countries in the global south region. Ethiopia is the second most populous country in Africa, with an estimated total population of 102 million people (FAO 2018). Majority (85) percent of the population are smallholder farmers who depend on subsistence production (FAO 2018). Similar with other developing countries, its economy is dependent on agriculture (MOFED 2010). Ninety five (95) percent of agricultural land is occupied by smallholder farmers who are responsible for producing more than 90 percent of the country's total agricultural produce, and 94 percent of its food crop volume (Gebresilasie and Bekele 2010).

Ethiopia has a federal system of government consisting of nine regional states and two city administrations that are delimited on the basis of settlement patterns, ethnic identity, linguistics and the consent of peoples (Ethiopian constitution article 46, sub-article 2). The vertical administrative hierarchy has five tiers: the national/federal level, regional states, zones, districts (hereafter called *woredas*), and municipalities (hereafter called *kebeles*). With the existing 'developmental state ideology' i.e. a system that fully lends itself to state-driven economic growth, government assume a more significant commitment to ensure the socio-economic development of the country (Bremes et al. 2015), and accelerating economic growth and eradication of poverty has recently been a priority development priority (MOFED 2010; Bremes et al. 2015). The national growth strategy, the Agricultural Development Led Industrialization (ADLI), is primarily aimed at strengthening the link between agriculture and industry through increasing smallholder efficiency and expanding large-scale private agricultural investment (MOFED 2010; Rahmato 2011).

Ethiopia is among the currently fastest growing economies in the world (Gebresilasie and Bekele 2010), and has set an ambitious plan of becoming a middle-income country by 2020-2025 (Bremes et al. 2015). With a reported eight percent annual growth rate (MOFED 2010),

the agriculture sector is the backbone of Ethiopia's national economy. The existing agricultural policy of the country aim to increase the production and productivity of commercial crops, smallholder transformation through increasing incomes and market integration, sustainable management of resources, and protection of rural communities from natural disasters and market risks (MOFED,2010; CRGE 2011). As a result of emphasis to increasing food production and productivity, agricultural output has been (reportedly) successively increasing over the last decade (MOFED 2010). Despite this, however, food insecurity in terms of the number, proportion and severity of food insecure people has been increasing, and nearly 10 percent of the population are currently severely food insecure (FAO 2017,18), while Ethiopia is among the highest recipients of food aid in the world (World Food Program 2013). Multiple factors including population growth (FAO 2017), recurrent drought (FAO 2017), economic instability (Keeley and Scoones, 2000), and absence of good governance (Gatzweiler 2005; Kefauver 2011; FAO 2017) are among the main threats to national food security.

Similar with many of developing countries, Ethiopia exhibits a high variability in agro-climatic zones and hosts a rich, wide range of biodiversity with a large number of endemic species (Kefauver 2011; USAID 2008). The country is a center of genetic and agricultural diversity of significant global importance (USAID 2008). However, biodiversity loss has been alarmingly accelerating due to high rates of habitat degradation and loss (Kefauver 2011; Gatzweiler 2005), which is largely attributed to anthropogenic factors such as agricultural expansion and deforestation (Kefauver 2011; Ayana 2014). While the main strategic focus is thus on Ethiopia's economic growth, biodiversity conservation has also been addressed, mainly by an increasing use of participatory resource management (Ayana 2014). Given the predominant smallholder-based agricultural economy of the country, but also the high and rising prevalence of food insecurity and biodiversity loss, understanding the key challenges to food security and biodiversity conservation urgently important and will help to inform appropriate interventions.

Food security and biodiversity condition in southwestern Ethiopia

The study area, Jimma zone (see Fig 1.1), is situated in Oromia region, ca. 350 km southwestern of the regional and national capital, Addis Ababa. Nearly 90 percent of the 3.1 million inhabitants of Jimma zone are smallholder farmers (OBFED, 2012). Smallholders here produce cereals and pulses as major food crops, while coffee (*Coffea arabica)* and khat (*Catha edulis)* are the two main cash crops (OBFED 2012). Farmers also strongly rely on forest-based ecosystem services to supplement their food demand, as various construction materials, and for

household energy demand (Ango et al. 2014). Smallholders in southwestern Ethiopia are relatively food insecure compared to international standards, although less so than people in the dry lowland parts of the country (CSA/WFP 2014). Southwestern Ethiopia is also known for its particularly rich biodiversity resources. Large parts of the landscape are covered by moist evergreen Afromontane forest (Friis et al. 2010; OBFED 2012) with an incredibly rich flora and fauna (Hylander and Nemomissa 2008), and it is also noted for being the birthplace of coffee (*Coffea arabica*). However, often caused by agricultural land expansion, accelerated biodiversity loss has been a major problem in the area (OBFED 2012).

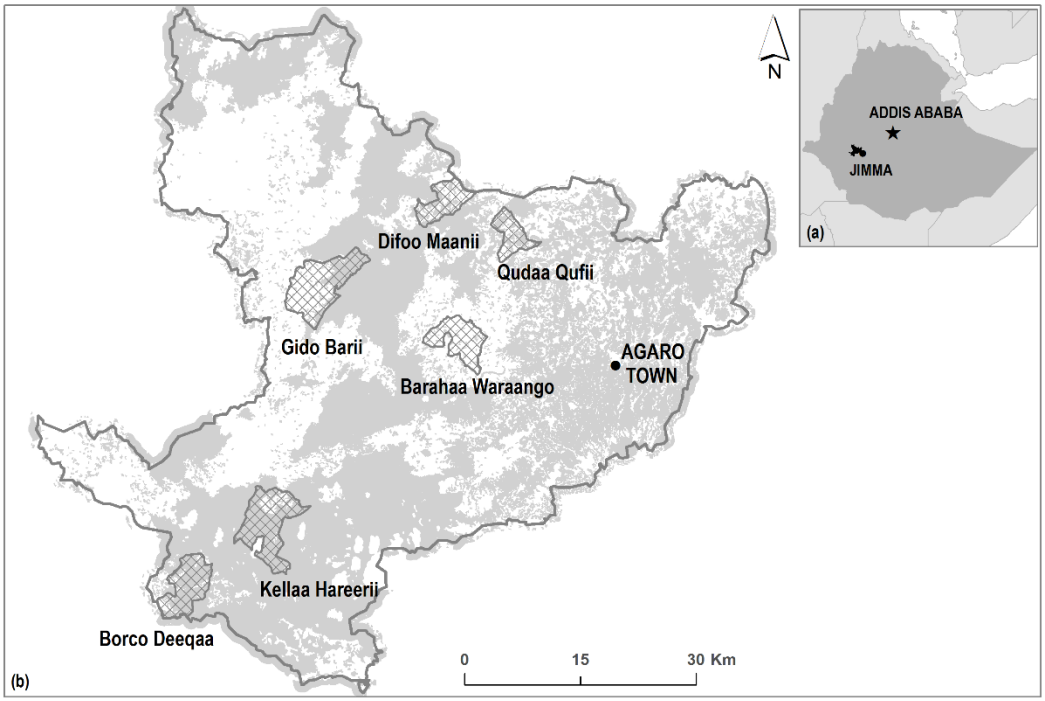

Figure 1.1. (a) Map of the study area in southwestern Ethiopia. **(b)** Map of Jimma zone and the six focal kebeles. Focus group discussions and community-level interviews were conducted in these six kebeles, which were purposively selected to cover a range of social and biophysical conditions within the study area. (Source: map made by Patricia Rodrigues)

Aims

The principal aim of this dissertation was to *identify the governance system properties that facilitate or impede food security and biodiversity conservation in the multi-level governance context of southwestern Ethiopia.* In order to address this overarching aim, this dissertation is divided into three sections. In **Section A** (Governance of agricultural land use), focusing on the governance dimension, I examine how food security approaches (Chapter II) and a popular agricultural land use framework, land sparing versus land sharing (Chapter III), unfold in the

local context of southwestern Ethiopia. **Section B** (Governance structures and processes), I focus on challenges to food security and biodiversity conservation in terms of structural governance challenges (Chapter IV) and procedural governance challenges (Chapter V). Finally, **Section C** (Future pathways) draws on a participatory scenario planning process to sketch out future development trajectories of the study area, with a focus on food security and biodiversity conservation (Fig. 1.2).

My specific aims were:

A. Governance of agricultural land use

   1. *How do global food security approaches unfold locally in the multi-level governance context of southwestern Ethiopia?*
   2. *How do agricultural land use frameworks unfold in the same context?*

B. Governance structures and processes

   3. *What are structural governance properties that facilitate or impede food security and biodiversity conservation?*
   4. *What are process-related governance challenges that facilitate or impede food security and biodiversity conservation?*

C. Future pathways

   5. *What are alternative pathways toward an integrated future achievement of food security and biodiversity conservation in southwestern Ethiopia?*

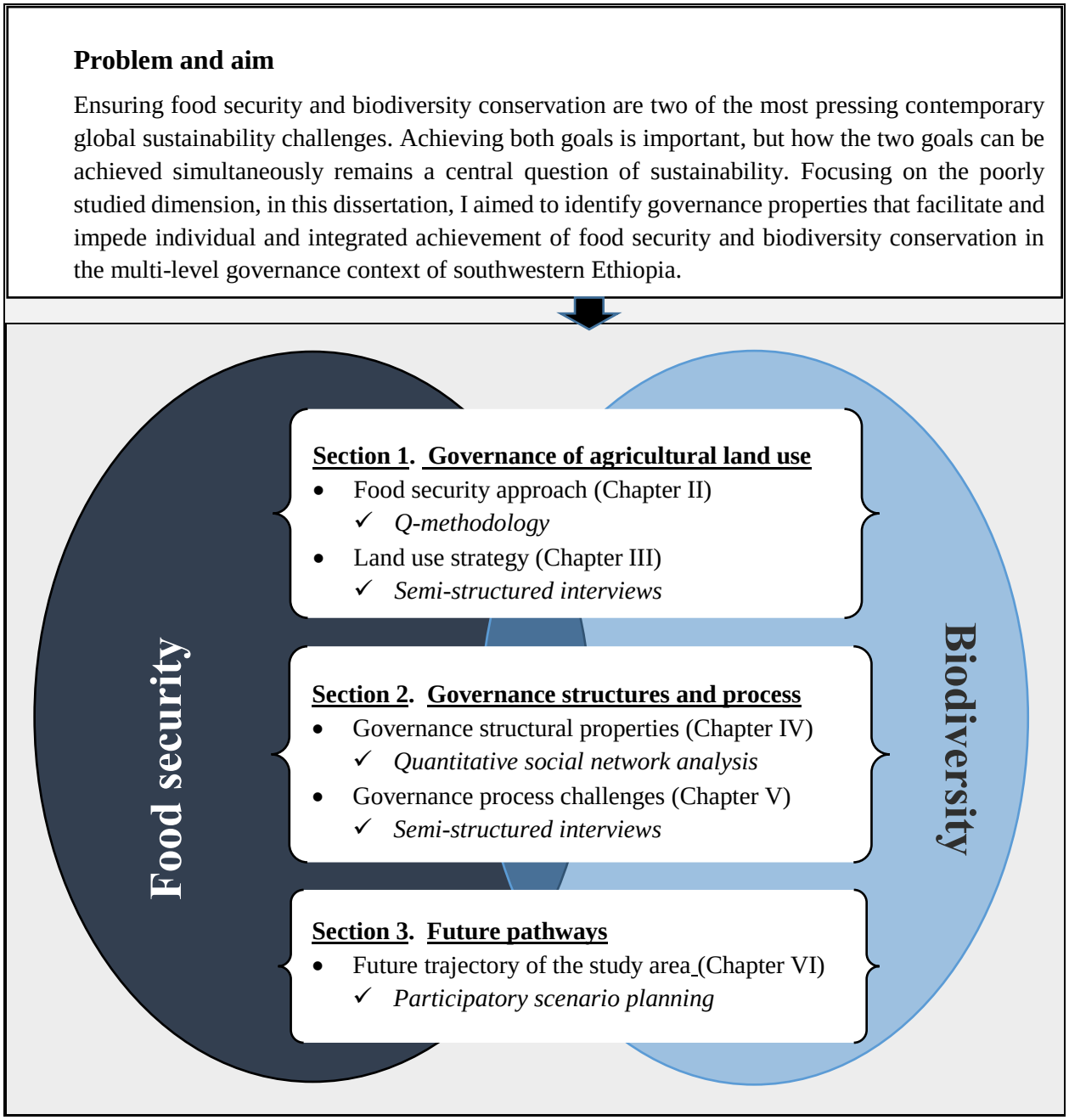

Figure 1.2.: Overview of the dissertation. The box at the top provides the problem statement and the overarching aim of this dissertation. The bottom box depicts how the integrated assessment of governance for food security and biodiversity conservation is framed for this study. The specific aims and the corresponding research methods that were applied during the research are also presented.

For this dissertation, I drew on a mixed methods approach involving both quantitative and qualitative methods. For aims 1 and 3, I applied quantitative methods, the Q-methodology and a social network analysis, respectively. For aims 2 and 4, I used semi-structured interviews, while aim 5 was addressed through participatory scenario planning. The particular procedures

applied are presented in detail in each respective chapter. In the following section, I summarize the findings of each papers included in this dissertation.

Summary of included chapters

Section A: Governance of agricultural land use consists of two chapters, the first one examining how global food security approaches play out at the local level (Chapter II), the second one investigating how agricultural land use frameworks unfold locally (Chapter III), both in the context of multi-level governance in southwestern Ethiopia including national, regional, zonal, woreda and kebele levels. This assessment is important because it addresses the poorly studied governance dimension of food security approaches and land use frameworks, and provides insights into the on-the-ground priorities and justifications as well as local capacity constraints that often remain overlooked in current food security approaches and land use frameworks.

Chapter II gives insight into the different approaches to food security including the extent to which various stakeholders invoke these approaches at different governance levels. Here, we applied a statement-based Q-methodology. We first identified, from the literature, four global food security discourses, namely the green revolution, the agricultural commercialization and efficiency optimization, the food sovereignty, and the resilience discourses. We prepared eight statements that represented core ideas of each of these discourses, which were then ranked by 50 stakeholder organizations from the woreda, zonal, regional and national governance levels. We applied principal component analysis to identify alternative approaches to food security in the study area.

The study thereby identified four distinctive food security approaches in the study area, which we named 1) *smallholder commercialization*, 2) *agroecology and resilience*, 3) *local economy and equity*, and 4) *market liberalization*. While some of these approaches, e.g. *smallholder commercialization*, strongly corroborated pre-identified global food security discourses, other approaches, e.g. *local economy and equity*, featured a mixture of elements from different global discourses. We illustrated that stakeholders' policy domain (i.e. food security or biodiversity) and governance level influenced the choice of food security approach. *Smallholder commercialization* was popular among stakeholders from the food security sector, and upheld intensive farming, commercialization and smallholders' economic prosperity as a pathway to food security. *Agroecology and resilience*, which was primarily supported by the non-governmental and biodiversity sector stakeholders, focused on diversified farming and

smallholder resilience to shocks and uncertainties. In contrast, the *local economy and equity* approach was dominantly backed by all but the national level stakeholders, and prioritized intensive farming and protecting smallholders from market competition. The *market liberalization* approach, finally, was supported by all except the region level stakeholders, and focused on global market integration and growing national income as a means to achieve food security.

A smallholder-centered development, as opposed to an expansion of investor-based, large-scale agriculture, emerged as a shared priority across all approaches. The focus on smallholder development was related to, among other things, the prevalence of smallholders and their vulnerability to the chronic level of food insecurity in the country. Despite this commonality, the four food security approaches differed in many aspects including how food security is framed, actors' constellation and governance system invoked, and pathways to food security. In general, all but the *agroecology and resilience* approach prioritized agricultural intensification, specialization, commercialization, and market integration as a means of achieving food security. In contrast, the *agroecology and resilience* approach focused on agroecological production, diversification, and multi-functional landscapes as a means of achieving food security. Our findings suggested that while acknowledging the plurality of approaches, it is essential to pay attention to and minimize the conflicting aspirations emerging from these approaches, for instance through greater stakeholders participation in policy decision-making process. Finally, we suggest that institutional support to the *agroecology and resilience* approach needs to be strengthened because both food security and biodiversity conservation benefit from features embedded within this approach.

In **Chapter III,** we investigated how the academically debated land use framework of land sparing versus land sharing strategies unfolds in the study area. Here, we focused on identifying stakeholder preferences of land use strategies and the rationales for such preferences as well as main challenges to the implementation of preferred land use strategies. For this, we interviewed 81 stakeholders representing community and stakeholder organizations from the kebele, woreda, zonal, regional and national governance levels. Preferences of land use strategies varied based on stakeholders' governance level, policy sector, and wealth of community members. Notably, policy making stakeholders, biodiversity sector stakeholders, and wealthy members of the community prioritized a land sparing strategy. Preference for land sparing was justified from ecological (e.g. needing strict protection of declining biodiversity resources) and

production perspectives (e.g. doubling food production to meet the nation's food demand). Other cross-cutting drivers such as an increasing human population were additional reasons for preferring land sparing. In contrast, land sharing was prioritized by policy implementers and poor community members. Among the main justifications for a preference of land sharing were social and cultural contributions of this strategy, e.g. its compatibility with local knowledge, but also a reduced risk of crop failure due to diversification practices. These findings highlighted that, beyond ecological and utilitarian values, land use decisions and preferences are largely shaped by socio-cultural issues. Our study also indicated that dualistic land use framings such as 'land sparing' versus 'sharing, which dominate the global discussion, have limited applicability at the local level. Instead, stakeholder preferences involved a third, 'mixed' land use strategy. This strategy was preferred by stakeholders at all levels, but mostly by policy makers from both food security and biodiversity conservation sectors. For these stakeholders, aspects from both land sparing and sharing strategies should be integrated and applied under the same land use system. Based on our results, we argue that land use strategies play a crucial role in integrating food security and biodiversity conservation, but that global dichotomous framings of land use on the basis of ecological justifications will seldom match the complexity encountered at the local level. Therefore, there is a clear need to consider multiple issues, including ecological, social, and governance dimensions, in strategic decisions over land use.

Section B: Governance structures and processes identifies the structural and procedural governance properties that facilitate or impede food security and biodiversity conservation and their integration. This assessment is important because it addresses the poorly studied governance dimension of food security and biodiversity conservation, and provides insights into the different governance challenges, that in turn inform intervention in the integrated governance of food security and biodiversity conservation.

In **Chapter IV,** we mapped stakeholder interactions, explored structural mechanisms for the integration of food security and biodiversity goals, and identified and characterized stakeholders according to their role in the network of multi-level governance in southwestern Ethiopia. Here, we first identified stakeholders following a bottom-up snowball technique starting from kebele and then proceeding to woreda, zonal, regional and national governance levels. To identify key properties of governance structure, we applied social network analysis. Specifically for the analysis of structural mechanisms for the integration of food security and

biodiversity goals, we discovered 12 distinct clusters of stakeholders with strong interlinkages. We then identified two structural mechanisms of integrating food security and biodiversity conservation, namely *individual integration* and *collaborative integration*. *Individual integration* occurred when a given stakeholder was simultaneously involved in both sectors, but formed interactions with other stakeholders separately within each sector. This was measured by computing the proportion of food security links of individual stakeholders relative to their total number of links and where proportions approaching the value of 0.5 meant that a stakeholder was equally involved in both sectors (and vice versa). *Collaborative integration* occurred when two stakeholders interacted simultaneously on both food security and biodiversity topics. We measured collaborative integration as the percentage of collaborations that involved both rather than a single topic.

We identified 244 stakeholders involved in the governance of food security and biodiversity conservation. The majority of them (80%) were governmental organizations. Our study also revealed that most of the stakeholders (71%) were simultaneously involved in the governance of both sectors. This finding suggests that a large number of stakeholders, coupled with their homogeneity (a majority of them being governmental organizations) could facilitate collective action. However, this homogeneity could also restrict plurality of perspectives, knowledge development and learning, thereby impeding the successful governance of food security and biodiversity. We further found that the governance network structure was strongly hierarchical, with no horizontal links between stakeholders across adjacent administrative boundaries, e.g. between woredas. Moreover, vertical links between stakeholders were also restricted to those governance levels immediately above or below. The absence of cross-boundary interaction limits stakeholders learning, collective action, and may thus cause an implementation deficit that affects the integration of food security and biodiversity conservation.

Interestingly, both *individual* and *collaborative integration* were found to be high. More importantly, both types of integration were high within clusters found at the implementation level (i.e. woredas and kebeles) and clusters that involved a diversity of stakeholders including governmental and non-governmental actors and local people. However, the low degree of *individual* as well as *collaborative integration* at the policy making governance level probably hampered the successful integration of food security and biodiversity conservation because policies are likely to target individual sectors rather than their integration. Finally, multipurpose stakeholders, those mandated with cross-cutting issues such as administration tasks, were

dominant in connecting stakeholders within (exhibiting a high so-called 'betweenness centrality') as well as between clusters (exhibiting a high so-called 'liaison brokerage'). Looking into the decision-making power of these connecting stakeholders, we found that these stakeholders had two sources of authority: the structural authority (central to the governance network), and the formal administrative authority which they held due to their administrative role. Given such authority, we highlight that connecting stakeholders have an opportunity to facilitate communication and collective action effectively. However, we caution that such authority can also lead to power capture and the manipulation of stakeholder interactions towards single-goal interests at the expense of fostering collective governance goals.

Chapter V elicited governance process challenges related to achieving each goal separately, i.e. only biodiversity conservation or food security, and achieving their integration. To identify these challenges, we interviewed 201 multi-level governance stakeholders. Qualitative content analysis produced three important categories of governance process challenges, namely institutional misfit, problem of institutional interplay, and policy incoherence. Some governance challenges manifested vertically between levels of governance, while others occurred horizontally between stakeholders of the same governance level. Within each main challenge, our study identified multiple more specific challenges, some exclusively occurring in a single sector while others transcended sectors. An overlapping and competing mandate of institutions (an institutional misfit), for example, was a major challenge in the governance of food security while limited institutional coverage (institutional misfit) characterized biodiversity conservation. Institutional instability and a frequent change in structure affected the integrated governance of food security and biodiversity conservation. Interplay challenges such as limited coordination among stakeholders were the most pressing governance challenge in both the individual sectors and their integration. Finally, an incoherence of policy goals between sectors, incompatibility of policy implementation strategies, and content-related incoherences between policies were prominent problems of single-sector as well as integrated governance. Our findings demonstrate that challenges related to the governance of food security and biodiversity were highly interdependent and reinforced each other in various ways. This highlights the need for integrated instead of single-target interventions to address governance challenges. Furthermore, our results showed that governance challenges identified in each individual sector also affected, and often more strongly so, their integrated governance. Based on our findings we indicate that the governance of multi-sector issues needs to consider the challenges inherent to each sector individually as well as in their integration.

Section C: **Futures pathways** explored future development trajectories for southwestern Ethiopia. In **Chapter VI**, we applied participatory scenario planning for the identification of key uncertainties driving changes in the area. Here, we conducted 24 separate stakeholder workshops for scenario development, validation and for communicating result. Multiple stakeholders, including local people and stakeholder organizations at the kebele, woreda, and zonal governance levels, participated in the workshops. Together with stakeholders we identified important drivers of changes for the study area for the past 20 years and plausible changes that might happen in the future. We identified 174 drivers of change, illustrated their interaction through causal loop diagrams, and identified important reinforcing or balancing feedback processes. This approach produced four plausible future scenarios for the study area: 1) *Gain over grain: local cash crops* envisioned a future where smallholders produce locally demanded cash crops, especially coffee, khat, and eucalyptus, primarily for commercial purposes; 2) *Mining green gold: coffee investors* envisaged a future where large-scale private agricultural investors produce coffee for the international market and where the landscape is dominated by coffee monocultures; 3) *Coffee and conservation: a biosphere reserve* represented a scenario where a biosphere reserve is established while food production follows the existing traditional farming system and is guided by agroecological practices; 4) *Food first: intensive farming and forest protection* sketched a future where smallholders intensively produce food crops to meet the national food demand while protected patches of forest remain in the landscape.

These scenarios differed distinctly with respect to dominating land use strategies and crops grown, actor constellations and governance mechanisms, and outcomes for food security and biodiversity conservation, and their integration. Three scenarios (except *Coffee and conservation: biosphere reserve scenario*) focused on intensive production, specialization and commercialization of crops. These types of agricultural production may increase food availability, but negatively affect food security in other ways such as a neglect of dietary diversity, a high risk of crop and market failures, and social inequality as poor people often lack the capacity to intensify farming. In addition to food security, such intensification pathways also pose a threat to biodiversity. In contrast, the *Coffee and conservation: biosphere reserve* scenario, involved features that are widely considered as beneficial to food security and biodiversity conservation, such as agroecological production, diversification practices, and increased social-ecological resilience. Although the economic gain from this scenario would not be as rapid as in the case of intensification, its emphasis on social justice through integration

of local knowledge and institutions makes this scenario highly relevant at the local level. In smallholder landscapes such as the one studied here, such a pathway that promises benefits for both food security and biodiversity conservation may need to be given greater emphasis.

Synthesis

This dissertation provides important insights into the governance properties that facilitate or impede food security and biodiversity conservation. Specifically, it demonstrates challenging differences in stakeholder preferences and justifications in the context of existing food security approaches and agricultural land use strategies. It also unveils important structural and procedural shortcomings in the governance of food security and biodiversity conservation. Finally, it provides novel, locally-sourced visions of development trajectories of southwestern Ethiopia with an emphasis on how to achieve food security and biodiversity conservation in the future. In this section, I discuss key cross-cutting and overarching findings from my dissertation work.

The need to step away from blueprint interventions: local dynamics matter

The findings of this dissertation indicate that a framing of agricultural land use as land sparing and land sharing has limited applicability in on-the-ground realities because agricultural landscapes are complex systems that consist of stakeholders with multiple and conflicting interests (Chapter III). The existing agricultural land use debate around land sparing and sharing is overly simplistic because important variables that influence agricultural land use decisions are not properly considered. For poor smallholder farmers whose livelihood is closely connected to agricultural land, social factors such as the compatibility of land use with their farming experience, traditional values, and cultural services are critically important factors (Chapter III) that are unaccounted for in existing global land use framings (Fischer 2008). Also, unlike the dichotomous framing of agricultural land use suggests, local land use preferences are not a matter of 'either/or', but instead involve mixed features exhibiting properties of both approaches (Chapter III, see also Chavez-Tafur et al. 2014). Similarly, Chapter II demonstrates that the choice of food security approaches varies between stakeholders and involves aspects from multiple global food security discourses. Agricultural land use decisions that lack recognition of local complexities could lead to interventions that have limited importance and may even exacerbate the problem they try to address (Young 2002; Borgström 2006; Collier et al. 2018). My findings strongly suggest the need for the consideration of local dynamics,

including the social and institutional dimensions of agricultural land use decisions (Chapter III, Chavez-Tafur et al. 2014).

Beyond the incompatibility of analytical framings, the different chapters of this dissertation further demonstrate the incompatibility of development interventions designed at the national level to the biophysical and socio-economic condition at the local level (Chapter V). A typical case is that development interventions are uniform across the region and follow the principle of 'one size fits all' solutions. These, however, fail to take into account important local variations including social factors such as stakeholder preferences, local capacities and (agro-ecological variability (Chapter V). Such incompatibilities arise mainly because of top-down governance structures (Chapter IV), limited participation of stakeholders in decision-making processes (Chapter V), and limited contextualization of interventions (Borgström 2006). Evidence elsewhere (e.g. in the water governance sector; Meinzen-Dick 2007; Ingram 2012) similarly indicates that there is no single panacea intervention, and that the success of development interventions greatly depends on its compatibility with the local context. For landscapes such as the one studied here, where stakeholder interests differ in various ways (Chapter II, III, and V), it is important that local dynamics are taken into account when designing interventions.

Embracing plurality of approaches while managing conflicts

Three of the four food security approaches identified in Chapter III were related to the notion of productivism. This notion widely frames food insecurity as a supply-side constraint and thus aims at increasing productivity (Koc 2013), prioritizing efficiency in food production (Shaw 2007; McKeon 2015), and commodification of food crops (Clapp 2015) often through agricultural intensification, specialization, and commercialization (Chapter II, III). Similarly, three of the four scenarios identified in Chapter VI envisioned some form of agricultural intensification. In addition to stakeholder preferences, Ethiopian national development policy has embraced the notion of productivism (Keeley and Scoones 2000; MOFED 2010), also for its future plans (Chapter VI, MOFED 2010), and mainly due to the strong support from policy influencing stakeholders, i.e. both national and international organizations (Chapters II and III). A similar trend has been observed in most Sub-Saharan African countries (AfDB 2011). On the other hand, although institutional support was minimal and often restricted to smallholders and green niche stakeholders, this dissertation unveils an alternative option to productivism, one that revolves around agroecology and resilience (Chapters II, III, V, VI) and is widely

embedded in the notions of food sovereignty and resilience (Nyéléni 2007; Pimbert 2009; Clapp 2015).

The dominance of the notion of productivism approach may increase food production, but impede the achievement of food security more holistically, such as through neglecting social justice, dietary diversity and stability (Shaw 2007; Fischer et al 2014), and biodiversity conservation (e.g. via habitat loss, land degradation, water pollution, and biodiversity loss; (Foley et al. 2011; McLaughlin 2011). Here, given the multiplicity of interests and diversities of local conditions, the dominance of the notion of productivism have a counterproductive social effects, e.g. an unaccounted preference of a majority of poor community members for an alternative food security approach (Chapter II, III). The findings from this dissertation suggest the need to embrace a plurality of approaches, for instance through strengthening alternative food security approaches (Chapter II), because such plurality better mirrors the diverse local realities and needs.

This dissertation further indicates that despite commonalities there are important conflicting perspectives between different food security approaches such as whether food is commodified or not (Chapter II), the importance of global market liberalization versus smallholder protection (Chapter II), market- versus state-led approaches to food security (Chapter II), and conflicting agricultural land use (e.g. where land sharing is the principal approach for poor smallholder farmers while land sparing is the primary choice by policymakers) (Chapter III). In this regard, these approaches pursue contradictory strategies, and currently co-exist in food security governance. Harmonizing these contradictions and bridging the gaps between alternative approaches is critical. This could potentially be achieved by acknowledging the need for plurality of approaches, and systematically integrating aspects from various approaches that are compatible with local conditions.

The diversity of stakeholders and their interactions facilitates integrated governance of multi-sector issues

Governance of complex social-ecological systems requires a diversity of actors (Baird 2018), and their collaboration across sectors and scales (Berkes et al. 2003; Bodin and Crona 2009). This study, focusing on the structural governance dimension in food security and biodiversity conservation, produced four essential insights with wider applications beyond the two focal topics. These insights relate to the structure of the governance network, the diversity of actors

and their links, the structural integration of multiple sectors, and the role of brokers in facilitating stakeholder interaction.

First, the contemporary governance literature suggests that the governance of complex multi-sector and multi-actor system requires a governance network structure that allows for plurality of stakeholders, collaboration across sectors and jurisdictions, and is flexible and adaptive to changes (Berkes et al. 2003; Bodin 2017). In Ethiopia, the governance of food security and biodiversity is characterized by a hierarchical system with mainly linear vertical linkages, lacking horizontal linkages between stakeholders that would transcend physically and ecologically connected administrative boundaries. This type of governance structure may not facilitate effective learning (Newig et al. 2010), but could instead foster both implementation deficits due to a disconnection of policymakers and policy implementers (Leventon and Antypas 2012) and institutional misfit due to an incompatibility between the institutional arrangement and the complex nature of food security and biodiversity conservation (Chapter V; Paavola et al. 2009; Galaz et al. 2008).

Second, while actors sharing similar perceptions most likely share strong ties (Prell et al. 2010), a diversity of actors and perspectives promotes learning, innovation and adaptive capacity (Bodin and Crona 2009; Moss and Newig 2010; Baird et al. 2018). In this dissertation, Chapter IV identified a large but relatively homogenous set of stakeholders, in that most of them were governmental organizations sharing similar perspectives and interacting among themselves. The low presence of other types of stakeholders, such as non-governmental organizations, limits learning opportunities for adaptively addressing the dynamic challenges inherent in the governance of food security and biodiversity conservation (Chapter IV). Confirmation for this comes from a related finding in Chapter V where institutional competition was found to be a major challenge of food security and biodiversity governance, which also elsewhere is a source of conflict and competition rather than cooperation and mutual trust (Bodin and Crona 2009; Baird et al. 2018).

Third, we introduced two key mechanisms of structural integration of food security and biodiversity conservation, individual stakeholder-level integration and collaborative integration (Chapter IV). While both mechanisms may enhance the harmonization of the two sustainability goals, increased attention needs to be given to especially collaborative integration as this form is particularly helpful in enhancing knowledge, innovation and learning toward integrated solutions (Björklund et al. 2012). In addition, individual-level integration may

impeded overall integration of food security and biodiversity conservation where it undermines stakeholders collaboration through producing redundancy and lacunae (Peters 1998).

Fourth, stakeholder positions in the governance network can facilitate or obstruct collective action, information flow, or link stakeholders that otherwise remain disconnected (Newig et al. 2010; Bodin 2017). Our analysis showed that stakeholders with structurally central positions that connected both stakeholders within the same cluster and stakeholders across different clusters, commonly held formal authority, i.e. they were administration organizations (Chapter IV). They were also (usually) mandated to coordinate between sectors, and thus were involved in both food security and biodiversity conservation (Chapter IV). These stakeholders, due to their popularity, central position in the network, and formal authority, can facilitate communication and coordinate stakeholders for collective action, which eventually may benefit food security and biodiversity conservation (Chapter IV, Adger et al. 2005; Hahn et al. 2006). Potential dangers in this context, however, lie in the possibility of power capture and an imposition of these powerful stakeholders' own interests at the expense of nurturing plurality of thoughts and perspectives.

An integrated approach is needed to address governance challenges in food security and biodiversity conservation

Our key findings identified three types of challenges in the governance of food security and biodiversity conservation, namely institutional misfit, the problem of interplay, and policy incoherences (Chapter V). These factors are also more generally considered to be threats to the successful governance of complex social-ecological systems (Young 2002; Galaz et al. 2008; Visseren-Hamakers 2015). More importantly, we found that institutional instability, limited participation, poor coordination, and an absence of good governance (e.g., accountability problems, and corruption) were the main specific challenges to food security and biodiversity conservation (Chapter V). These issues were closely interdependent and tended to reinforce each other (Chapter V). Equally notable is that nearly all challenges that affected a single sector (i.e. food security or biodiversity) also tended to strongly affect their integrated governance (Chapter V). Given the complex interdependence of governance challenges, coupled with the complexity inherent to food security and biodiversity conservation, attempts to achieve the dual goal thus not only demands integrative interventions, but also a flexible and rapidly responding governance system (Hess and Ostrom 2007; Galaz et al. 2008; Guerrero and Wilson 2016).

Outlook for future interventions

Based on the findings of my dissertation, in this sub-section, I provide key insights into the proper identification and addressing of governance challenges related to food security and biodiversity conservation. Recognizing the interdependence of food security and biodiversity conservation, the need and presence of opportunities for their harmonious achievement, and addressing the challenges in a way that matches local dynamics, all are essential to coordinate efforts towards the integrated governance of food security and biodiversity conservation (Fischer et al. 2008; Wittman et al. 2016). Failure to recognize these issues, in turn, could lead to the design and implementation of interventions that inadequate to achieve the sustainable goals of food security and biodiversity conservation.

Agricultural land use is an important issue at the interface of food security and biodiversity conservation. It is characterized by multiple and competing interests, and complex interactions between the biophysical and the social system. To reconcile the goal of food security and biodiversity conservation, trade-off analyses such as the land sparing and sharing framework which seek to optimize either goal have limited applicability. This dissertation illustrates that, given the interdependence and multidimensionality of food security and biodiversity conservation, existing agricultural land use framings are overly simplistic and do not sufficiently consider important variables such as social and governance factors. Instead, understanding the dynamic interactions of food security and biodiversity conservation requires a holistic analytical lens that enables the identification of properties that benefit both food security and biodiversity conservation (Wittman et al. 2016). One potential lens is the emerging 'integrated landscape approach' as an alternative way of identifying and addressing the challenges around food security and biodiversity conservation (Chavez-Tafur et al. 2014; Bürgi et al. 2017); it enables the contextual examination of landscape scale social-ecological interactions, can be used to identify system properties that benefit food security and biodiversity conservation, and can help to design appropriate policy interventions (e.g., through multi-stakeholders participation).

As indicated in the different chapters of this dissertation, multiple challenges affect the successful achievement of the individual and integrated goals of food security and biodiversity conservation. Existing food security approaches usually prioritize agricultural intensification, specialization and commercialization as means of achieving food security. As indicated in the synthesis section above, agricultural intensification poses a threat to not only biodiversity

conservation, but also to the sustainability of food security. There is therefore a clear need to acknowledge and provide institutional support to alternative agroecological production approaches, as they could both provide balanced solutions to food security and biodiversity conservation but also better answer to the interests of the majority of smallholders. One such possible pathway may involve the scaling-up of sustainable practices of modern organic agriculture (Warner 2007) and the strengthening of emerging green-niche institutions (Järnberg et al. 2018).

Among critically important challenges to the governance of food security and biodiversity conservation were a lack of stakeholder coordination across sectors and geographic boundaries, conflicting stakeholder interests on land use, limited stakeholder diversity and linear governance structure, an incompatibility of development interventions with the demands of local people, and an absence of good governance. Because these governance challenges tend to reinforce each other, more holistic and collaborative governance interventions are needed that ensure institutional fit, stakeholder participation, pay attention to the diversity of interests, and ensure stakeholder coordination across different policy domains. Although there is no one 'silver bullet' intervention, structural governance arrangements that ensure communication, learning and trust, and that foster cooperation across governance scales, levels, and sectors (Ostrom, 2010), may help to overcome most of the identified challenges in the study area. In this context, collaborative governance is a promising system because it encourages participation of diverse stakeholders across governance levels, reconciles divergent interests through consensus building, builds trust through regular communication, enables collaboration transcending geographic boundaries and sectors, and facilitates communication, learning and innovation (Ansell and Gash 2007; Bodin and Crona 2009; Newig et al. 2010; Bodin 2017). For instance, the gap in the preference of land use strategies between stakeholders at the policy and the implementation levels may require greater participation and consensus building among the stakeholders. But while collaborative governance can be key to addressing such multifaceted governance challenges, its adaptation should be carefully matched and contextualized to the existing social-ecological system (Bodin 2017).

Finally, transdisciplinary studies can be powerful tools in understanding and addressing existent challenges in the governance of interlinked sustainability issues. They not only facilitate the necessary understanding of the multidimensional issues inherent to social-ecological systems but also make their findings relevant to policy and practice in the real world

(Chapter VI). In this dissertation, for example, we iteratively engaged local community, practitioners, policy makers, and experts from multiple disciplines in the identification of critical uncertainties, devised plausible future scenarios, and deliberated on how to create a desirable future that would ensure food security and biodiversity conservation (Chapter VI). Beyond empowering the community, e.g. through enabling them to articulate their views and proactively think about their future, our transdisciplinary engagement enabled stakeholders to develop a mutual trust and develop a common future vision of their landscape (Chapter VI).

Conclusion

This dissertation focused on the governance dimension to identify properties that benefit and impede food security and biodiversity conservation in the multi-level governance setting of southwestern Ethiopia, an area characterized by food insecurity and biodiversity loss. It provided important insights in three key aspects. First, both food security and biodiversity conservation are complex on their own nature, and the need for their integration further adds complexity. This dissertation highlighted that the navigation of pathways that harmoniously ensure food security and biodiversity conservation requires a holistic analytical lens because existing frameworks are partial and too simplistic. Second, this dissertation explained that governance structures and processes need to be compatible with the complex nature of food security and biodiversity, and that the existing governance system tends to ignore such complexity. Third, the dissertation portrayed that, in the face of uncertainty, scenario development could enable stakeholders to proactively prepare for such changes related to the most important issues of the landscape, food security and biodiversity conservation. In addition, although existing agricultural practices predominantly tend to benefit either of the goals, this dissertation identified a clear opportunity to advance agroecological practices because they may balance food security and biodiversity conservation goals and are compatible with smallholder experiences and traditions.

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Section A: Governance of agricultural land use

Two chapters of this section investigate how the global food security approaches (Chapter II) and land use framework (Chapter III) locally unfold in a multi-level governance setting involving national, region, zone, woreda and kebele levels. This study is important because, in addition to addressing the poorly studied governance dimension, it provides an insight into the on-ground priorities and justifications regarding different food security approaches and land use framework

Chapter II

Chapter II

Alternative discourses around the governance of food security: a case study from Ethiopia

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In Review in Global Food Security

Limmu Seka waterfall, Jimma

Highlights

- Local preferences for food security approaches involve a mix of global discourses
- Existing policy and most stakeholders favor conventional agricultural intensification
- Only green niche actors support an agroecology and resilience approach
- Most food security approaches pay limited attention to biodiversity conservation
- Food security interventions should better consider local dynamics and environmental issues

Abstract

Global discourses on the governance of food security span competing approaches. For example, a neoliberal approach advocates commercialized, industrial agriculture, while food sovereignty and resilience are part of an alternative discourse to food security that prioritizes locally-based agroecological food production. Understanding how global discourses play out locally and how they impact the environment and biodiversity is important to identify appropriate pathways towards sustainability. In addition to their effects on food security, different approaches could reinforce or impede the success of biodiversity conservation because of the strong interdependence of food security and ecosystems. We applied the Q-methodology to examine alternative approaches to food security and biodiversity conservation pursued by 50 stakeholders from local to national levels in southwestern Ethiopia. We identified four distinct approaches, focusing on (1) smallholder commercialization, (2) agroecology and resilience, (3) local economy and equity, and (4) market liberalization. All approaches prioritized smallholders, but perspectives on how to achieve food security varied. Agricultural intensification, commercialization, and profit were widely considered important, while support for agroecology and resilience was largely restricted to non-government organizations. With the exception of supporters of the agroecology and resilience approach, biodiversity conservation was considered as a secondary goal. We conclude it is important to acknowledge plurality of food security approaches because local conditions are characterized by a multiplicity of stakeholder interests, and because food security is a complex problem that requires a multidimensional approach. However, major contradictions among existing approaches need to be reconciled, and the agroecology and resilience approach should be strengthened to ensure the sustainable achievement of food security and biodiversity conservation.

Keywords: **Food security; Food sovereignty; Green revolution; Market liberalization; Resilience; Smallholder commercialization**

Introduction

Ensuring food security is a central aspect of the sustainable development goals (UN 2015) and of the development agenda of the African Union (FAO 2012; African Union Commission 2015). The World Food Summit defined food security as "a condition that exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for a healthy and active life" (WFS 1996). In the context of this study, we conceptualized food security as universal access to sufficient, safe, and culturally acceptable food, without negative effects on biodiversity. Here, we included the issue of biodiversity because food security and biodiversity goals are strongly interdependent (Chappell and LaValle 2011), and thus approaches that address food security could either reinforce or impede achieving the goal of biodiversity conservation (Fischer et al 2014). Hence, our study sought to uncover how approaches to ensuring food security could also affect biodiversity conservation. Universally the goal of food security is widely agreed upon, uninterruptedly ensuring the availability and accessibility of food to all people. However, the approaches to achieve this goal remain deeply contested (Shilomboleni 2017). Current literature indicates two influential but opposing approaches: a green revolution and commercialization approach versus a food sovereignty and social-ecological resilience approach (McKeon 2015; Wittman 2011).

In Africa, the green revolution approach has become prominent since the beginning of the new millennium, supported by major corporations and humanitarian organizations such as the Rockefeller Foundation and the Bill and Melinda Gates Foundation who established the Alliance for a Green Revolution in Africa (Blaustein 2018). The approach aimed to achieve food security through increasing crop output per unit area, a transformation from subsistence to commercial agriculture, and the adoption of hybrids and genetically modified organisms (DeVries and Toenniessen 2001; Rockefeller Foundation 2006). This approach focuses on the supply of agricultural technology and extension services, arguing that efficiency gains can be achieved through technology adoption by farmers and improved access to inputs such as crop breeds, irrigation technology and fertilizers, and output markets (Toenniessen et al. 2008). Despite considerable success in transforming rural economies in Asia and Latin America (Dawson et al. 2016), important downsides of the green revolution approach have been, for instance, greater income inequality, high costs of inputs, community conflicts and environmental degradation and biodiversity loss (Shiva 1991, Amir 2013). Initially, the green

revolution approach had not been successful in Africa, primarily due to its incompatibility with local cultures and ecological conditions (Dawson et al. 2016). However, it has once again gained prominence due to infrastructural development (Ejeta 2010), institutional support such as through the Alliance for a Green Revolution (Bill and Melinda Gates Foundation 2017), the need to produce more food for a growing population (Shilomboleni 2017), and the belief of African governments in yield increases as a panacea for food security (Africa Development Bank 2014).

An alternative to this corporate based neoliberal approach builds on the discourse of socially inclusive, sustainable and biodiverse systems to ensure food security. This is often captured by the concept of food sovereignty, which focuses on the right of local people to determine what to produce and consume, values local experiences and local control of resources and food systems, and seeks to work with nature through diversified farming systems (Nyéléni 2007; La Via Campesina 2013). The food sovereignty approach is most prominently supported by civil society organizations such as La Via Campesina or the Alliance for Food Sovereignty in Africa (La Via Campesina 2013; Alliance for Food Sovereignty in Africa 2014). Inclusive decision making involving diverse stakeholders is integral to the food sovereignty approach (Shilomboleni 2017). Despite its social-ecological focus, the food sovereignty approach has been criticized because it poorly considers the pressures stemming from exponential human population growth (Shilomboleni 2017).

While these two opposing approaches dominate food security discourses, additional, slightly different framings also exist. For instance, especially in Africa, some policies specifically favor agricultural commercialization (NEPAD 2003). This overlaps with a green revolution framing but is subtly different because it specifically aims for the efficient production of marketable crops based on the principles of comparative cost advantages. In addition, an agricultural commercialization approach sees markets as a source of agricultural transformation, whereas the green revolution approach often considers the state as a key agent of agricultural transformation (including providing training and advice on the choice of crops, inputs and production methods). In contrast, an agricultural commercialization approach views farmers (including smallholders) as critical agents, who make production decisions based on cost efficiency and contract extension services as required (Van Den Ban and Hawkins 1996). Similarly, a resilience framing can be identified as distinct from a food sovereignty framing. This approach typically takes a complex adaptive systems perspective, emphasizing feedbacks,

slow drivers of systems behaviour, and emergent system dynamics resulting from self-organization (Fischer et al. 2015). A food sovereignty approach, in contrast, is more explicitly concerned with the power relations between actors than traditional resilience thinking is (West et al. 2014).

The above discussion thus shows different potential pathways towards food security – including green revolution, food sovereignty, commercialization and resilience approaches. These approaches differ in how to achieve food security, particularly with regard to issues such as food production methods, the role of biodiversity, marketing and governance. Making these different pathways with their specific discourses and different levels of policy and institutional support explicit is, in turn, crucial to successfully navigating contradictions and to collectively work towards sustainable ways of achieving food security. In addition, understanding who supports which approach gives an understanding of current power relations around food systems, making explicit which aims and goals different system actors pursue, and hence, allowing for the identification of promising and widely acceptable interventions.

Here, we examine the extent to which different food security discourses are invoked by different stakeholders in southwestern Ethiopia. Ethiopia is a highly food insecure country, and has engaged various approaches to overcome food insecurity (Järnberg et al. 2018). Moreover, the country is also characterized by high rates of biodiversity loss (Husen et al. 2012), driven among others, by population growth, deforestation, and climate change. Ethiopia could be considered as an important case study area because of growing food insecurity and frequent changes in approaches designed to address the problem of food insecurity (Jiren et al 2018). Different approaches were adopted sequentially, following various political and economic changes (e.g. from command-and-control policies to neoliberalism, and recently to a developmental state policy that puts the state at the center of ensuring food security), but several approaches to food security currently co-exist. Under the present Developmental State development paradigm (Brems et al. 2015), policy goals include: increasing the production and productivity of commercial crops, smallholder transformation through increasing incomes and market integration, sustainable management of resources, and protection of rural communities from natural disasters and market risks. These approaches have been embedded in various policy frameworks, including the Rural Development Policy and Strategy of Ethiopia (MOFED 2003), the Comprehensive Africa Agricultural Development Program (NEPAD 2003), the

Climate Resilient Green Economy (CRGE 2011) and Growth and Transformation Plans (MOFED 2010).

This paper seeks to delineate existing discourses on food security in southwestern Ethiopia, while paying particular attention to the different roles ascribed to biodiversity conservation in these discourses. To this end, we applied the Q-methodology. Our specific aims were to: (1) identify and characterize different approaches to food security pursued by stakeholders from local to national levels; (2) examine the rationale and narratives behind these approaches; and (3) identify ways to bridge gaps between the different discourses, so that meaningful communication among stakeholders is possible.

Methods

Study location

The study was conducted in southwestern Ethiopia. Ethiopia has a federal government structure with five levels of administration: national, regional and zonal levels, districts (hereafter "woredas"), and municipalities (hereafter "kebeles"). We interviewed stakeholders from three woredas (Gumay, Gera, and Setema), and from the zonal (Jimma), regional (Oromia) and national levels (Table S2.1). Jimma zone exhibits strong interactions between food insecurity and biodiversity, and the three woredas were selected to represent social-ecological diversity within the zone (Jiren et al. 2017).

Design

We used the Q-methodology to elicit different discourses on ensuring food security, including their implications for biodiversity. The Q-methodology assists in exploring varied discourses about a particular topic through a combination of quantitative and qualitative methods. Q-methodology has been applied to numerous fields (Bredin et al. 2015). The method included five main steps: identifying the range of discourses around food security (as known as framing the concourse), development of statements that represent each of the existing discourses (known as Q-set), selection of sample stakeholders (known as P-set), collection of data resulting from a ranking activity carried out by the stakeholders (known as Q-sorting), and analysis and interpretation of the result (Watts and Stenner 2005).

As highlighted in the Introduction, we initially identified four primary discourses relevant to food security, namely framings around: (1) green revolution (Shiva 1991; Dawson et al 2016),

(2) agricultural commercialization and efficiency optimization (IFAD 2003; FAO 2013), (3) food sovereignty (Nyéléni 2007; McKeon 2015), and (4) resilience (Folke 2006). Drawing on literature, policy documents and with the help of Ethiopian and international experts, we iteratively formulated statements that together captured each of the four discourses—including their aims, principles, practices and core values. Following an initial brainstorming, we reviewed and merged statements that had similar meanings. Through a subsequent refining process, we ultimately formulated eight written statements representing each of the four primary discourses labeled above to define a 32-item Q-set (Table 2.1).

In designing Q research, stakeholder selection should cover a diversity of actors, to ensure multiple discourses are captured. Our samples were stakeholder organizations represented by their senior personnel. These stakeholders were purposively selected from sectors around food security and biodiversity conservation operating at different governance levels (woreda, zone, region, and national). Also, the sample stakeholders represented different organizational types including governmental organizations, non-governmental organizations and community-based organizations. The selection of stakeholders was guided by prior knowledge of the actor network around food and biodiversity issues (Jiren et al. 2018), and aimed to capture a variety of viewpoints. Although the P-set size in Q-methodology is usually kept lower than the Q-set, we sampled 50 stakeholders (Table S2.1) in order to represent the diversity in food security approaches and governance levels (Milcu et al. 2014).

Data collection

Data collection for the Q-method (Q-sort) included the ranking of the Q-sets into a forced quasi-normal distribution reflecting a priority of rankings. The selected 32 statements of the Q-set were carefully translated into the local language Afaan Oromo. We then randomly assigned a number to each statement and placed each statement on an individually laminated card that could be placed on a scoreboard by the respondent (Fig. S2.1), without disclosing the a priori category of food security discourse each statement represented. The scoreboard represented a quasi-normal distribution in a double pyramid (diamond) shape, ranking from +4 (most important) to -4 (least important; see Fig. S2.1).

Before the start of the interview respondents were given information about the study and the interview procedure, and were asked for consent for recording the interview. Respondents were first asked to read all the 32 statements and prioritize them into the three categories ‘most important’, ‘medium important’ and ‘least important’, according to the priorities of the

stakeholder being represented. Second, after pre-sorting, we asked the respondent to place the cards on the scoreboard according to their priorities of importance. Instead of placing the cards from top (most important) to bottom (least important), we asked them to switch between the most important and then the least important statements. Thus, respondents would first place the most important statements (+4 and +3), then the least important statements (-4 and -3), and lastly the medium important statements (+2 to -2). This helped the respondents to focus on the extremes, rather than getting lost at intermediate importance scores early on. Third, after the completion of the sorting exercise, respondents were given time to re-read and re-order the statements if they wanted to change their original sorting. Fourth, after finalizing the Q-sort, we asked respondents three qualitative follow-up questions: (1) What are the justifications for the eight most and the eight least important statements? (2) What are the challenges for the implementation of these prioritized statements? (3) Are there any other issues worth mentioning regarding food security that were not included in the Q-set?

Data analysis

To identify variation in the approaches explained by the 50 stakeholders (Q-sorts) regarding the approaches to food security, we performed both quantitative and qualitative analyses. First, a multivariate analysis of the Q-sorts was performed in order to identify distinct approaches towards food security (so called factors) (see Akhtar-Danesh 2017). For the multivariate analysis, we chose principal component analyses (PCA) using the "qmethod" package in R software. We applied PCA because it considers both commonalities and specificities among the 50 Q-sorts (Webler et al., 2009), gives similar results to other plausible methods such as centroid factor analysis (Watts and Stenner 2012), and is readily implementable in statistical software. We applied a varimax rotation to the PCA, which is a standard approach to improve clarity and interpretability of the factors; and we flagged Q-sorts that were representative of the resulting factors (Zabala 2014). In this process, after an initial exploration of three, four and five factor solutions, we finally extracted four factors because the patterns of explained variance as seen in the scree plots was optimal, the eigenvalue was high, and the four factors coherently explained the variation in perspectives regarding how to achieve food security across the Q sorts (interpretability of the factors).

Thirty-nine of the 50 Q-sorts significantly loaded on one of the four approaches. The Q-sorts loading on a particular approach were treated as having a similar opinion concerning the approaches towards achieving food security. The four approaches identified were then

interpreted in terms of commonality of Q-sorts within the approach, and the classifications of statements that loaded highest and lowest on a given approach.

The qualitative data obtained from the follow-up questions were transcribed from field notes and audio recordings. The transcribed data were analyzed through content analysis in NVivo 11. We first created one node for the justifications and one node for the challenges. Under each of these nodes, we created four sub-nodes representing each of the four identified approaches. We then inductively coded justifications and challenges from the transcribed sources under each of the approaches.

Results

Overview of discourses

We identified four approaches that reflected alternative discourses for how to achieve food security in southwestern Ethiopia: *Smallholder commercialization* (16 stakeholders), *Agroecology and resilience* (7 stakeholders), *Smallholder economy and equity* (9 stakeholders), and *Market liberalization* (7 stakeholders). The 39 stakeholder opinions that characterized these approaches (Table S2.1) collectively explained 47.7% of the variance (Table 2.1). Correlations between the four approaches were low indicating that they differed distinctly (Pearson correlation ≤ 0.4). In the following, we characterize each approach regarding its main focus, stakeholder support, problem framing, as well as highlighting justifications and challenges for implementation.

Characterization of different approaches

Approach 1: Smallholder commercialization

This approach supported smallholder economic growth through intensive production of commercial crops. The approach was supported by stakeholders at all levels (Fig. 2.1A), dominantly by the food sector stakeholders (Fig. 2.1B), with only governmental and community-based stakeholders (Fig. 2.1C).

The approach entailed a discourse of smallholder income and profit maximization from agricultural intensification (i.e. use of agro-chemicals) and agricultural commercialization to ensure food security. Statements of profit maximization and green revolution were ranked as most important (Table 2.1). “Increasing farmers’ income through commercialization” and

"Shifting smallholders from subsistence to profit maximization" were the two highest ranked statements (Statements 30 and 6 in Table 2.1). Stakeholders in this approach believed that food insecurity could be resolved by increasing production through agricultural intensification, farmers' ownership of production assets such as land, and adoption of agricultural technologies supplied by the government (Statements 20, 24 and 27 in Table 2.1). Considered as not important by stakeholders in this factor were statements around diversified and agroecological production (Statement 4 in Table 2.1), social-ecological resilience (Statements 1 and 31 in Table 2.1), large-scale private agricultural investment (Statements 18, 22 and 25 in Table 2.1), and government interference in market and resource control (Statements 8 and 14 in Table 2.1).

Qualitative results showed that all stakeholders pursued this approach because it aligned with the national growth policy and their official mandate (Table S2.2). Stakeholders also felt that smallholders constituted a large population, and transforming their livelihoods therefore was a key priority. A woreda-level respondent explained: *"Development interventions that disregard the vast majority of smallholders risk failure. Increasing smallholders' financial capacity and access to resources is the right way to develop the nation*". Belief in positive associations between modern agriculture, commercialization, smallholder growth and food security were important justifications (Table S2.2). Consequently, priority was usually given to food security over biodiversity conservation. A woreda-level respondent explained: *"People conserve biodiversity, but first people need to be fed by all possible means"*. Finally, poor capacity of farmers (lack of land and unwillingness to change) and policy implementers (lack of expertise), and costs of agricultural modernization (e.g. fertilizer) were perceived to hamper the successful implementation of the approach (Table S2.3).

Approach 2: Agroecology and resilience

This approach argues for the application of agroecological methods for improving food production and social-ecological resilience as a pathway to ensure food security. The approach was supported only by stakeholders above the zonal level, mainly at the national level, where most of the sampled stakeholders were affiliated with the biodiversity sector (Fig. 2.1A). All stakeholders were from the biodiversity conservation sector (Fig. 2.1B), involving both governmental and non-governmental organizations (Fig. 2.1C).

Important statements involved sustainable management of social-ecological resources and enhancing the resilience of the system, focusing on three main issues in particular (Table 2.1).

First, the interdependence and complexity as well as the need for collaborative management of social-ecological systems were recognized and prioritized (Statements 31, 29, 1, and 4, Table 2.1). Second, agroecological methods such as diversified agricultural production and diversified livelihoods were seen as a means of achieving food security (Statement 28, Table 2.1). Third, participatory and pluralistic local governance, and respect for local knowledge, cultures, experiences and value systems were emphasized (Statements 10, 2, and 7, Table 2.1). In contrast, the expansion of large-scale private commercial agriculture (Statements 22, and 14, Table 2.1) and state control of resources were ranked very low in this approach. Agricultural modernization, intensification and commercialization, and liberalization of markets were also considered unimportant for food security (Statements 18, 12, 28, Table 2.1).

Stakeholders loading onto this approach indicated the importance of ecosystems and biodiversity to provide essential products and services for ensuring food security, and hence rejected the notion of agricultural intensification (Table S2.2). Moreover, 86% of stakeholders supporting this approach believed that by utilizing local people's experience, knowledge and capacity, they can change their condition and ensure food security (Table S2.2). Institutional gaps and a lack of coordination between stakeholders, a policy emphasis on intensification, and lack of proper policy and institutional support were seen as main limitations to implement this approach (Table S2.3).

Approach 3: Local economy and equity

This approach integrates aspects from the two previous approaches but had a stronger focus on local development and equity as means to achieve food security. The approach was supported by stakeholders from all the governance levels except the national level (Fig. 2.1A); both food security and biodiversity conservations sectors (Fig. 2.1B); and included governmental and non-governmental organizations (Fig. 2.1C).

This approach integrated agricultural intensification and smallholder commercialization (Statements 20, 26 and 32, Table 2.1) with the need to identify and manage unpredictable and complex changes affecting social-ecological systems (Statements 1, and 29, Table 2.1). In addition, local production, local marketing and a closed market system that protects local products from external competition were other distinctive features of this approach (Statement 19, Table 2.1). Proponents of this approach focused on the importance of culture, experience and value systems of the community, and strongly acknowledged the right of all people to have

sufficient and preferred food (Statements 2, and 9, Table 2.1). Diversified production was considered the least important for achieving food security (Statement 4, Table 2.1). Farmers' ownership of production resources such as land, the determination of market prices by farmers or the state, and market liberalization were also considered unimportant (Statements 11, 12, 14, 15, 24 and 17, Table 2.1).

Key characteristics for this approach were the empowerment of smallholder farmers through intensive and commercial production, and enhancing income from increased production in combination with protection from international competition (Table S2.2). To achieve this, adoption of improved technologies supplied by the government were emphasized. In addition, skepticism on the efficiency of state and market, impacts of large-scale private investment on equity, and the recognition of the interdependence between social and ecological systems were mentioned as important reasons to support this approach (Table S2.2). The implementation of this approach was found to be hampered by internal factors such as unwillingness of the local community, poor expertise of implementers, as well as external factors such as threats of population growth and climate change (Table S2.3).

Approach 4: Market liberalization

This approach emphasized the role of agricultural research and innovation, agricultural intensification, commercial production, and smallholder integration into regional and international markets to generate income, profit and accumulate wealth. Stakeholders supporting this factor were from the woreda and zone level (Fig. 2.1A), from both the food security and biodiversity conservation sectors (Fig. 2.1B), and from both governmental and non-governmental organizations (Fig. 2.1C).

The focus of this approach was on the production of marketable crops based on the comparative advantage principle to maximize profits through integration into liberalized markets (Statements 30, 12, 23 and 6 Table 2.1). It shared similar priorities with *approach 1* through supporting profit maximization; with *approach 2* through emphasizing the management of slow changes affecting the social-ecological system; and with *approach 3* through agricultural intensification. However, the focus on trade liberalization and open markets distinguished this approach from the previous three approaches. Smallholders' rights to choose what to produce and to determine the market price for their produce were typically considered unimportant (Statements, 11, 19, 2, 17, and 3, Table 2.1).

The emphasis and compatibility with current trade policies (i.e. focus on import substitution and export promotion) were given as the main justification (Table S2.2). Similar to the other approaches, supporting stakeholders did not belief in a benign state, but rather considered excessive state intervention as a market distortion. They therefore objected to state intervention in both resource allocation and market determination (Table S2.2). Perceived limitations of implementing this approach were weak and missing market facilities and institutions (Table S2.3).

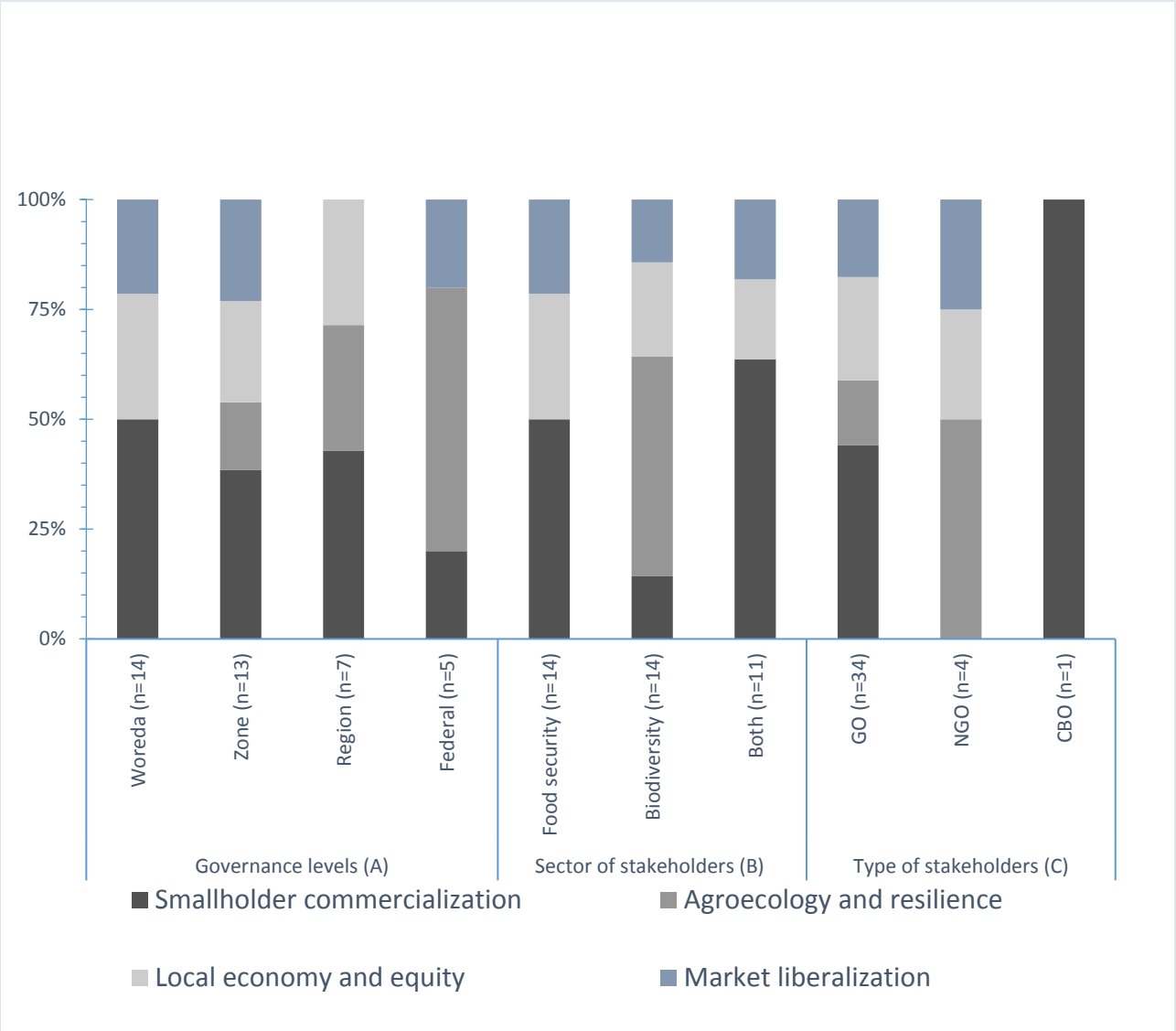

Fig. 2.1. Frequency distribution of factor defining Q-sorts (n=39) for the different approaches to food security. Governance level (A) indicates the distribution of approaches to food security in the four administrative levels (woreda, zonal, regional or national level). Sector of stakeholder (B) indicates the responsibilities and tasks with which the stakeholders were engaged (food security, biodiversity, or both sectors). Type of stakeholder (C) indicates whether stakeholders belonged to governmental (GO), non-governmental (NGO), or community based organizations (CBO).

Discussion

Our study indicated four different approaches to food security, namely smallholder commercialization (a technological-economic discourse), agroecology and resilience (a social-ecological discourse), local economy and equity (a social-economic discourse), and market liberalization (a macroeconomic neoliberal discourse). These approaches combined and emphasized different aspects of the four pre-identified framings, that is, the green revolution, agricultural commercialization, food sovereignty and resilience approaches. Especially the local economy and equity approach represented a mixture of the pre-identified framings. It combined aspects from the smallholder commercialization approach and market liberalization approach – e.g. of agricultural intensification and commercialization – while also sharing aspects of the agroecology and resilience approach, such as the need to identify and manage unpredictable and complex changes.

Our study revealed that, although food sovereignty is rapidly gaining traction as a globally important framing (Patel 2009), this discourse was largely absent from our results. This means that, at this point, the notion of food sovereignty was not an important priority in the study area. This could be because, in our study area and possibly other similar locations facing regular food shortages, strong priority is given to increasing food production without much concern to the right of smallholders to determine what food to produce and how. The popular belief that 'food precedes human rights and democracy' was reflected by the policy influencing national and international stakeholders, and was also popular among the local level stakeholders at the district level. In addition, dissatisfaction with existing low yielding traditional practices may have directed stakeholder preferences towards industrial farming, rendering food sovereignty a low priority.

Our findings also indicated that, while aspects of some of the approaches were clearly supported by existing institutions—the smallholders commercialization approach, local economy and equity approach, and market liberalization approach had strong institutional support— other aspects are only beginning to emerge in policy discourses—most notably, the agroecology and resilience approach had little traction among local actors. This indicates that the dominance of a given approach depends on the capacity and power of supporting stakeholders (Leach et al. 2010). In the following sections, we discuss the similarities and

differences between the different approaches, as well as implications for bridging gaps between them.

Commonalities among approaches to food security

All approaches prioritized smallholder development as an important focus to ensure food security, which is in line with the Ethiopian Rural Development Policy and Strategy (MOFED 2003) and the regional Comprehensive Africa Agricultural Development Program (NEPAD 2003). This could be because smallholder farmers are vulnerable to food insecurity and also occupy a large area of farmland. Moreover, in all approaches large-scale private agricultural investments were considered to be socially inequitable and ecologically unsustainable. Most importantly, this consensus contradicts with Ethiopia's current investment policy trajectory, which prioritizes expansion of large-scale private agricultural investment (Rahmato 2011; MOFED 2002). Whether such large-scale private agricultural investment or smallholder-based agriculture better ensures food security remains contentious (Shete and Rutten 2015). Critics of large-scale private investment highlight its social costs such as income inequality, expropriation and biodiversity loss (Yengoh et al. 2014). Studies in African countries, such as Mozambique (Milgroom 2015), Sierra Leone (Fatoma 2017) and Ethiopia (Rahmato 2011) and in Latin America (Borras et al 2010) have indicated major social costs of large-scale private investment. On the other hand, large-scale private agricultural investments are often welcomed by national governments because they generate surplus production, foreign earnings, and facilitate technology transfer (Brüntrup et al. 2016; Poulton 2012).

Another point of consensus was the call to limit the role of the state in agricultural markets, which might have been triggered by a perceived governance inefficiency (Helal 2016). However, limiting the role of the state contradicts with official framings of the political economy of Ethiopia – its "Developmental State" paradigm explicitly seeks and justifies a strong role for the state (Brems et al. 2015). Clearly, this mismatch between national policy priorities on the one hand, and the preferences expressed by actual stakeholders on the other hand, requires attention in the future.

Tensions among approaches to food security

The four approaches showed clear differences regarding problem framing, interventions, resource ownership, and the perceived role of biodiversity (Table 2.2). First, problem framing is key for justifying interventions and solutions in a given approach. In our findings, key

problem framings were seen in subsistence-based farming and farm inefficiency (smallholder commercialization); pressures of slow changes such as population growth, climate change and land degradation (agroecology and resilience); institutional problems such as power inequalities (local economy and equity), and poor market integration of smallholders (market liberalization) (Table 2.2). These different problem framings emphasize dynamics that are playing out at different spatial and temporal scales. Moreover, all framings can be found in current policy documents around food insecurity in Ethiopia. Also, other countries have at a different times emphasized one or multiple of these framings. For instance, in Sub-Saharan Africa, supply side challenges to food security due to the subsistence farming, and poor farm technology (Ilaboya et al. 2012; Garnett 2013) were considered obstacles to achieving food security. Similarly, land degradation, climate change and population growth (FAO 2017), power asymmetries between global actors (McKeon 2015), poor market integration of smallholders (Barrett et al. 2009) and combinations of these were seen as common reasons for food insecurity elsewhere. Multiple problem framings around food security align with the complexity, multiplicity and multi-sector nature of food security, and could help in addressing different dimensions of food security. While acknowledging such plurality to address multiple facets of food security, countries would benefit when the frictions and contradictions between the problems framing of these approaches are explicitly addressed. For example, within our study area, the market liberalization approach favors the integration of smallholders into regional and global markets, whereas proponents of the local economy and equity approach fiercely oppose it.

Based on different problem framings, the approaches derived distinct interventions and solutions (Table 2.2). Promoting more intensive farming and improving the wealth of smallholders, for example, were priority interventions for proponents of smallholder commercialization. These priorities are associated with the Green Revolution and Agricultural Commercialization discourses, which place a high priority on production and income (Shiva, 1991) and which are consistent with the existing growth policy of Ethiopia (MoFED 2003). Critics of this discourse have pointed out that the social and ecological aspects of food security are seldom addressed (McKeon 2015; Hodbod and Eakin 2015). In contrast, the agroecology and resilience approach focused on building social-ecological resilience through diversified farming and management of slow change variables such as population growth, climate change, and land degradation. This approach finds its support in the academic sphere of resilience thinking (Folke 2006; Järnberg et al. 2018), usually for its balanced social-ecological outcomes

(Berkes 2017). Unlike other approaches, policy attention to this approach was minimal due to a perceived limited production efficiency and the resulting slow economic growth (Isgren and Ness 2017). In addition to this limitation in policy attention, we found no local level stakeholders (i.e. at the district level) supported to the agroecology and resilience approach. This finding contested the popular understanding that sees a strong association between local level stakeholders and traditional ecological knowledge (Menzies 2006). A likely reason is that many local level stakeholders still represented (national) government interests and paradigms, which currently do not place a high importance on traditional ecological knowledge.

For the local economy and equity approach, interventions prioritized local food production for domestic markets to ensure equity and protect smallholders from external market competition. This discourse builds on smallholders' self-sufficiency, which has been criticized as limiting potential gains from international trade and foreign earnings (FAO 2002). Highlighting poor market integration as a cause of food insecurity, the market liberalization approach endorsed neoliberal perspectives (Wittman 2011; McKeon 2015), seeking to integrate smallholders into regional and international markets through removing economic barriers such as tariffs and environmental regulations. Broadly, these discourses correspond to two competing views: a productivism and neoliberal view (advocating smallholder commercialization and market liberalization) versus a localized entitlement view (agroecology and resilience, and aspects of the local economy and equity approaches). Whereas the former approach entails top-down interventions and is backed by powerful global actors such as the World Trade Organization (WTO), the Rockefeller Foundation, and the Bill and Melinda Gates Foundation (Amir 2013; Wittman 2011), the latter intervention find its support in grass-roots initiatives such as La Via Campesina and Alliances for Food Sovereignty movements (McKeon 2015; Wittman 2011).

Perspectives on resource governance such as land tenure and ownership also reflected differences between the four approaches (Table 2.2). Proponents of smallholder commercialization and market liberalization approaches believed that efficient allocation of land could be better addressed when the land ownership is vested to smallholder farmers. Market mechanisms such as the introduction of a land market were also believed to determine the real value of land and ensure the efficient allocation to different land uses. According to this view, state intervention in land governance was associated with smallholder expropriation. In the context of African countries a stronger emphasis on market mechanisms has been proposed because it is believed to facilitate efficient land allocation and arguably might support

smallholder access to financial services through the collateral benefits of land (Holden and Ghebru 2016). However, critics of this view argue that marketing land would mainly lead to a transfer of land from the poor to the rich elites, thereby impeding local equity. Building on this, proponents of the local economy and equity approach strongly supported state ownership of land because the state can ensure equity through land redistribution, and thus regulate elite capture (Sjaastad 2003). The land policy of Ethiopia falls under this category (FDRE constitution 40(3)). Perspectives within the agroecology and resilience approach favored integrated governance of land by multiple actors across multiple governance levels. In this view, land ownership of land provides a basis for smallholder resilience, and therefore collaborative governance was seen as appropriate (Cotula 2009).

Finally, the identified food security approaches also varied regarding biodiversity conservation. In all approaches, except the agroecology and resilience approach, biodiversity was either considered a secondary priority or only important if directly linked to food security. This view of biodiversity conservation largely disregards the multi-layered interdependence of food security and biodiversity (Fischer et al. 2017; Glamann et al. 2015). In addition, this view often principally focuses on the availability dimension of food security while other components such as distributional and procedural justice are neglected. Thus, in three of the four approaches identified in this paper, food security and biodiversity conservation are implicitly treated as conflicting goals, and biodiversity is considered only when it directly contributes to food security – missing the crucial supporting and regulating roles of biodiversity that are vital for the long-term sustainability of food systems. Only the agroecology and resilience approach supported an idea of food security that does not imply a trade-off with biodiversity, but rather emphasizes interdependence of the two goals. Importantly, however, the agroecology and resilience approach had no institutional support at the district or local level, and this institutional gap at the implementation level could exacerbate problems related to biodiversity loss and environmental degradation. With social-ecological resilience receiving increasing attention by scholars (Folke 2006; Wittman et al. 2016), it is important to also pay more attention to issues of agroecology and resilience in practice.

Outlook: bridging gaps

We showed that global food security discourses unfold into multiple and partly overlapping approaches at the national and sub-national levels. We also indicated that preferred food security approaches are not uniformly endorsed by all stakeholders in a given country. Even

stakeholders in the same policy sector and governance level sometimes had strongly divergent preferences, clearly indicating the need to better reconcile currently competing interests. We identified four approaches that support distinct strategies for how to ensure food security. While development centered on smallholder farmers was a common denominator, the approaches differed with regard to problem framing, means or intervention strategies, resource governance, and biodiversity conservation. Acknowledging this diversity in approaches is essential to address the multifaceted aspects of food security. For instance, the smallholder commercialization and local economy and equity approaches favored the intensive agriculture and commercialization aspects of the neoliberal discourse, while the market liberalization approach subscribed to the trade and profit aspects of the neoliberal discourse. The institutional base to these three approaches involved pro-economic growth institutions ranging from local to national levels with the capacity to influence national food policy. In contrast, the agroecology and resilience approach backed diversified production and social-ecological resilience as a preferred pathway to food security. Institutions from a single sector, pro-environment and non-governmental organizations with limited power backed this approach.

In the context of the governance of food security, three main issues need further emphasis. First, the focus on intensive production, commodification and income as a pathway to food security appears to be the dominant discourse among stakeholders. This discourse has been widely accepted and will continue to dominate the institutions around food security in Africa (Africa Development Bank 2016; Alliance for a Green Revolution in Africa 2017), largely due to its strong support from international philanthropic organizations and the ambition of the national governments to accelerate economic growth in GDP terms. However, elsewhere this discourse has been associated with conflicts, inequality and environmental degradation (Shiva 1991; Dawson et al. 2016). Thus, in addition to food production, it is essential that greater emphasis is given to social-ecological resilience and sustainability, for example through strengthening the institutional base of the agroecology and resilience approach.

Second, proponents of the smallholder commercialization, local economy and equity, and market liberalization approaches, considered biodiversity conservation as a secondary goal because they rarely recognized the multi-layered interdependence between food security and biodiversity. We argue that integrating the two sectors is essential for a sustainable outcome. The proponents of the agroecology and resilience approach supported the integrated governance of both sectors but their focus was primarily on achieving ecological resilience.

Here it would be important to explicitly emphasize an appropriate balance between ecological and social resilience.

Third, we indicated that multiple approaches with contradictory perspectives currently co-exist in food security governance. Harmonizing these contradictions and bridging the gaps between these alternative approaches is essential. This could potentially be achieved, for example, through systematically integrating those aspects from all approaches that are compatible with local conditions in a particular focal system. This could be possible through collaborative governance mechanisms that promote multi-stakeholder participation, collective action and coordination across policy sectors.

We emphasize that there is no panacea to food security, and solutions need to be context specific. However, designing the governance structures and processes that ensure institutional interactions and coordination across multiple sectors and governance levels to integrate diverse views, discourses and approaches towards food security is important. Adaptive co-management of food security could be one way to harmonize contradictions, integrate divergent discourses and interests, bridge current gaps and incorporate multiple framings to open a pathway for sustainability.

Table 2.1. Four approaches to food security by southwestern Ethiopian stakeholders, as identified by Q-sorting of pre-defined statements, and their associated weighted average Z-scores that indicate the relationship of statements to each approach. The first column indicates the initial category of pre-defined discourse statements that were Q-sorted by stakeholders, i.e. the resilience discourse (RS); the food sovereignty discourse (FS); the green revolution discourse (GR); and the agricultural commercialization discourse (AC). The second column indicates the 32 statements (Q-sets) used to identify different approaches by stakeholders to food security, where eight statements were provided for each initial discourse category. The Z-scores, the weighted average value of how each statement associates with the four approaches, are presented in the final four columns. A double asterisk (**) indicates the eight highest ranked statements in each of the approaches, a single asterisk (*) indicates the 26 intermediate-ranked statements in each of the four factors, and no asterisk indicates the eight least important statements for each approach.

#	Initial discourse category	Statement (Q-sets)	Z-score of statement in the four approaches			
			Smallholder commercialization	Agroecology & resilience	Local economy & equity	Market liberalization
1.	RS	Social-ecological systems are unpredictable and should be managed so that they can cope with unexpected changes.	-0.87	1.33**	0.72**	1.61**
2.	FS	Community culture, values and traditions should be considered as integral parts of local development.	0.49*	1.01**	1.06**	-1.09
3.	FS	Farmers should be supported technically and financially, so that they are empowered to independently manage their own resources.	-0.52*	0.81*	-0.55*	-1.03

4.	RS	Food should be produced in diversified systems, using agro ecological methods rather than conventional intensification methods.	-1.96	1.31**	-2.41	-0.76
5.	FS	Recognition, respect and appropriate compensation should be given to smallholder farmers, including in national policies and strategies.	-0.43*	0.62*	0.59*	-0.13*
6.	AC	The primary goal of farmers should be to maximize profits from agriculture.	1.35**	-0.24*	-0.21*	0.85**
7.	RS	Agricultural methods should be continuously improved and updated on the basis of the experiences of the local community.	-0.08*	0.89**	-0.39*	-0.13*
8.	GR	Land and other production resources should be controlled by government agencies.	-1.98	-1.61	-0.37*	-1.90
9.	FS	Food should be considered a human right, and everyone has a right to access it.	0.89*	0.46*	1.64*	-0.24*
10.	RS	Local governance should be pluralistic and participatory, involving government actors, non-government actors and community groups.	-0.35*	1.11**	0.12*	-0.26*
11.	FS	Farmers should have full autonomy to decide what to grow and how to grow it.	0.32*	0.43*	-1.91	-1.61
12.	AC	Policies and strategies should focus on the expansion of trade, investment and economic growth, by paying careful attention to export and import dynamics.	-0.27*	-1.45	-0.64	1.05**
13.	RS	Social cohesion, networking and information sharing should be promoted for local development.	0.05*	0.86*	-0.02*	0.07*

14.	GR	Government should help to stabilize markets, including by setting input and output prices.	-2.18	-1.02	-1.60	-1.94
15.	GR	Expansion of financial and infrastructural services and capital assets should be a key priority.	0.79**	-0.26*	-0.59	0.08*
16.	GR	Food security should be ensured through increased agricultural production and through raising farmers' incomes.	1.15**	-0.05*	0.16*	0.23*
17.	FS	Farmers should be able to set the market price of their produce without the influence of external forces.	0.32*	-0.09*	-0.82	-1.04
18.	AC	Land use efficiency should be enhanced through the promotion of commercial farming.	-0.67	-1.42	-0.97	0.03*
19.	FS	Locally produced foods, not imported foods, should be the primary source of food in Ethiopia.	-0.52*	0.25*	1.41**	-1.33
20.	GR	Farmers should transform to modern agriculture through use of fertilizer and herbicides, insecticides, improved varieties and farm mechanization.	1.13**	-1.38	1.55**	0.19*
21.	GR	Research and science should focus on developing high yielding varieties to be diffused to farmers.	1.33**	-0.64*	0.45*	0.76*
22.	AC	Private investment should be encouraged and expanded in the agricultural sector.	-1.24	-0.83	-0.39*	0.13*
23.	AC	It is important to grow marketable crops and increase the yield of these crops.	0.5*	-0.43*	0.13*	1.03**
24.	FS	Farmers should have the full right to access and control production resources and assets, such as land, capital and labor.	1.11**	0.52*	-1.33	-0.67*

25.	AC	Large-scale agricultural investment and large farms should be promoted to facilitate economic growth	-0.91	-1.32	-0.15*	0.58*
26.	GR	The primary task of extension agents should be dissemination of new scientific knowledge in order to enhance its adoption by farmers.	0.45*	-0.77*	1.48**	1.79*
27.	GR	Government should supply and control agricultural and extension services.	0.83*	-0.66*	0.55*	-0.56*
28.	RS	Diversified income sources and livelihood strategies should be encouraged.	0.58*	1.14**	0.50*	0.14*
29.	RS	Social and ecological changes that affect local development should be identified, monitored and managed – including slow changes such as population growth or soil degradation.	-0.47*	1.50**	1.20**	1.14**
30.	AC	The income of farmers should be increased through the promotion of commercial farming and agricultural intensification.	1.59**	-0.99	0.31*	1.32**
31.	RS	Social and ecological systems are complex systems, and should be managed through integrated, cross-sectoral solutions.	-0.67	1.70**	-0.18*	1.23**
32.	AC	Farmers should transform towards market-oriented production systems, including smallholder commercialization.	0.21*	-0.82*	0.66**	0.45*
	Variance explained (number of Q-sorts that defined this factor)		12.8% (16)	12.8% (7)	12.7% (9)	9.4% (7)

Table 2.2. Differences between the four approaches to food security in terms of problem framing (the perceived underlying causes of food insecurity), focus of intervention (perceived solutions), governance modes (mechanisms to implement interventions), biodiversity conservation (how conservation is viewed in these approaches), land ownership (entitlement and decision over the production resources), and policy prescription and normative prescriptions and assumptions (the recommendations from each approach).

#		**Approaches**			
	Indicators	**Smallholder commercialization**	**Agroecology & resilience**	**Local economy & equity**	**Market liberalization**
1.	**Problem framing**	Subsistence farming, and limited use of agricultural technologies	Threats of slow changes, and conventional farming	Subsistence farming, and social inequality	Subsistence farming, and weak or missing domestic market
2.	**Focus**	Getting smallholders wealthier though small-scale commercial and intensive farming (technological-economic discourse)	Getting smallholders resilient to shocks and uncertainties through diversified farming (social-ecological discourse)	Ensuring smallholders protection and equity through intensification and local market (social-economic discourse)	Liberating market, and growing national income with trickle down effects to smallholders (macroeconomic neoliberal discourse)
3.	**Governance modes**	Market (local, regional and international)	Integrated governance	Market (local)	Market (global)

4.	**Biodiversity conservation**	Grow crops first, then take care of biodiversity	Conserve biodiversity because it is the basis of food security	Balance between economy and ecology	Protect environment and manage changes that hamper economic growth
5.	**Land ownership**	Local people's ownership	Joint control and decision over land	State ownership	Market determination
6.	**Policy prescription and normative assumptions**	Smallholder commercialization and intensive farming	Strong emphasis on management of environmental resources	Social equity and balanced growth	Market liberalized and increasing GDP

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Supplementary Tables

Table S2.1. Overview of stakeholders that participated in the study, including the stakeholder's name, governance level and location, type of organization (governmental, non-governmental or community-based organization), and stakeholders' sectoral affiliation (food security sector only, biodiversity sector only, or both sectors). Factor loading stakeholders are designated by a double asterisk (**).

#	Name of stakeholder	Governance level (location)	Type of organization	Affiliation of stakeholder
1	Bureau of Agriculture and Natural Resource Management **	Woreda (Gumay)	Governmental	Both
2	Land and Environmental Protection Office **	Woreda (Gumay)	Governmental	Both
3	Irrigation Development Authority	Woreda (Gumay)	Governmental	Food security
4	Coffee and Tea Development and Marketing Authority **	Woreda (Gumay)	Governmental	Food security
5	Cooperative Promotion Agency **	Woreda (Gumay)	Governmental	Food security
6	Trade and Market Development Bureau**	Woreda (Gumay)	Governmental	Food security
7	Arga Farmers Union	Woreda (Agaro)	Community-Based Organization	Food security
8	Bureau of Agriculture and Natural Resource Management **	Woreda (Gera)	Governmental	Food security
9	Irrigation Development Authority **	Woreda (Gera)	Governmental	Food security
10	Cooperative Promotion Agency**	Woreda (Gera)	Governmental	Food security
11	Coffee and Tea Development and Marketing Authority **	Woreda (Gera)	Governmental	Food security
12	Micro and Small Enterprise Development Agency **	Woreda (Gera)	Governmental	Food security
13	Bureau of Agriculture and Natural Resource Management **	Woreda (Setema)	Governmental	Food security

14	Cooperative Promotion Agency**	Woreda (Setema)	Governmental	Food security
15	Women and Children's Affairs Office **	Woreda (Setema)	Governmental	Food security
16	Disaster Prevention and Preparedness Commission **	Woreda (Setema)	Governmental	Food security
17	Oromia Forest and Wildlife Enterprise **	Woreda (Setema)	Governmental	Biodiversity conservation
18	Bureau of Agriculture and Natural Resource Management	Zone (Jimma)	Governmental	Both
19	Irrigation Development Authority**	Zone (Jimma)	Governmental	Food security
20	Land and Environmental Protection Office	Zone (Jimma)	Governmental	Both
21	Limmu Investment Group P.L.C. **	Zone (Jimma)	Community-based	Food security
22	Ethiopian Agricultural Research Institute	Zone (Jimma)	Governmental	Both
23	Disaster Prevention and Preparedness Commission **	Zone (Jimma)	Governmental	Food security
24	Oromia Forest and Wildlife Enterprise **	Zone (Jimma)	Governmental	Biodiversity conservation
25	Institute of Biodiversity Conservation **	Zone (Jimma)	Governmental	Biodiversity conservation
26	Japan International Cooperation Agency	Zone (Jimma)	Non-governmental	Both
27	Plan International Ethiopia **	Zone (Jimma)	Non-governmental	Both
28	Women and Children's Affairs office	Zone (Jimma)	Governmental	Food security
29	Investment Commission **	Zone (Jimma)	Governmental	Food security
30	Environment and Forest Research Center**	Zone (Jimma)	Governmental	Biodiversity conservation
31	Deutsche Gesellschaft für Internationale Zusammenarbeit**	Zone (Jimma)	Non-governmental	Biodiversity conservation
32	Coffee and Tea Development and Marketing Authority **	Zone (Jimma)	Governmental	Food security
33	Cooperative Promotion Agency**	Zone (Jimma)	Governmental	Food security
34	Irrigation Development Authority	Region (Oromia)	Governmental	Food security

35	Livestock and Fish Resource Development Bureau	Region (Oromia)	Governmental	Food security
36	Oromia Forest and Wildlife Enterprise **	Region (Oromia)	Governmental	Biodiversity conservation
37	Bureau of Agriculture Crop Production Section**	Region (Oromia)	Governmental	Food security
38	Cooperative Promotion Agency **	Region (Oromia)	Governmental	Food security
39	Disaster Prevention and Preparedness Commission	Region (Oromia)	Governmental	Food security
40	Agricultural Growth Program **	Region (Oromia)	Non-governmental	Food security
41	Bureau of Agriculture and Natural Resource Management(NRM section) **	Region (Oromia)	Governmental	Biodiversity conservation
42	Land Administration Environment Protection Bureau**	Region (Oromia)	Governmental	Both
43	Environment, Forest and Climate Change Bureau**	Region (Oromia)	Governmental	Biodiversity conservation
44	Coffee and Tea Development and Marketing Authority	Region (Oromia)	Governmental	Food security
45	Ministry of Agriculture and Natural Resources**	National (Ethiopia)	Governmental	Both
46	Movement for Ecological Learning and Community Action**	National (Ethiopia)	Non-governmental	Both
47	Ethiopian Institute of Biodiversity**	National (Ethiopia)	Governmental	Biodiversity conservation
48	Institute of Sustainable Development **	National (Ethiopia)	Non-governmental	Biodiversity conservation
49	Ministry of Forest, Environment and Climate Change**	National (Ethiopia)	Governmental	Biodiversity conservation
50	Wildlife Conservation Authority**	National (Ethiopia)	Governmental	Biodiversity conservation

Table S2.2. Stakeholders' justifications for their chosen approach to food security. For each approach, the percentage of stakeholders is given that used a given justification. For instance, all of the respondents of the smallholder commercialization approach explained that they prioritized certain statements because they aligned with existing policy, institutional and organizational support.

#	**Justification**	**Smallholder commercialization (%)**	**Agroecology & resilience (%) (n=7)**	**Local economy & equity (%)**	**Market liberalization (%) (n=7)**
1	Policy, institutional and organizational support	100	43	45	100
2	Agricultural intensification and commercialization promote efficient resource allocation and thus enhance smallholder growth	69	-	45	100
3	Farmers lack capacity and willingness, thus requiring the government to persuade them towards agricultural intensification	50	-	78	-
4	Transformation of smallholder farmers requires respecting the cultures and values of the community	44	-	-	-
5	Agricultural technologies, science and research are a backbone of growth	57	-	78	-
6	Smallholder income is the driver for food security and development in general	75	-	-	-
7	The state is not entirely benign and it should not control resources nor interfere in markets	69	-	78	100
8	Large scale agricultural investments undermine the sustainable nature conservation and inclusive growth	19	71	78	29
9	Caring for ecosystem management follows ensuring food security	44	-	-	-

10	Complex-social-ecological systems require integrated and adaptive governance	-	43	-	-
11	Sustainable use of resources leads to social-ecological systems management and resilience	-	43	-	-
12	Nature conservation through farm diversification helps to contain threats such as climate change and land degradations	-	57	33	-
13	Slow changes cause large harm and need to be managed to overcome development barriers	-	43	-	71
14	Proper functioning of the ecosystem is crucial for overall development	-	100	-	57
15	Agricultural commercialization harm both ecosystem and social system	-	100	-	-
16	Farmers have wisdom and experience to manage their resources	-	86	-	-
17	Stakeholder plurality is crucial for development	-	43	22	-
18	Food security and surplus production depends on the speed and intensity of agricultural production	-	-	33	-
19	Farmer's empowerment through local production and farmers protection	-	-	100	-

Table S2.3. Challenges for the implementation of each approach to food security, as mentioned by stakeholders, and the percentages of stakeholders mentioning the challenge. For instance, 11 out of the 16 respondents in the smallholder commercialization approach explained that limited capacity of farmers was among the main challenges for the implementation of their preferred approach.

#	**Challenge**	**Smallholder commercialization (%) (n=16)**	**Agroecology & resilience (%) (n=7)**	**Local economy & equity (%) (n=9)**	**Market liberalization (%) (n=7)**
1	Poor capacity of farmers	69	-	-	57
2	Unwillingness of farmers	44	-	56	57
4	Implementers lack capacity	69	43	67	71
5	Policy and local demand mismatch	19	-	33	-
6	Commercialization is costly	13	-	-	-
7	Market fluctuations	25	-	22	-
8	Lack of awareness about ecosystems by development interventionists	-	43	-	-
9	Missing institutions and poor coordination	-	57	-	-
10	Government induced growth strategy and dependency on external inputs	-	57	-	-
11	Population pressure, climate change and resource degradation	-	29	45	43
12	Lack of access to agricultural technologies	19	-	11	-
13	Lack of coordination and missing market infrastructure	-	-	-	57

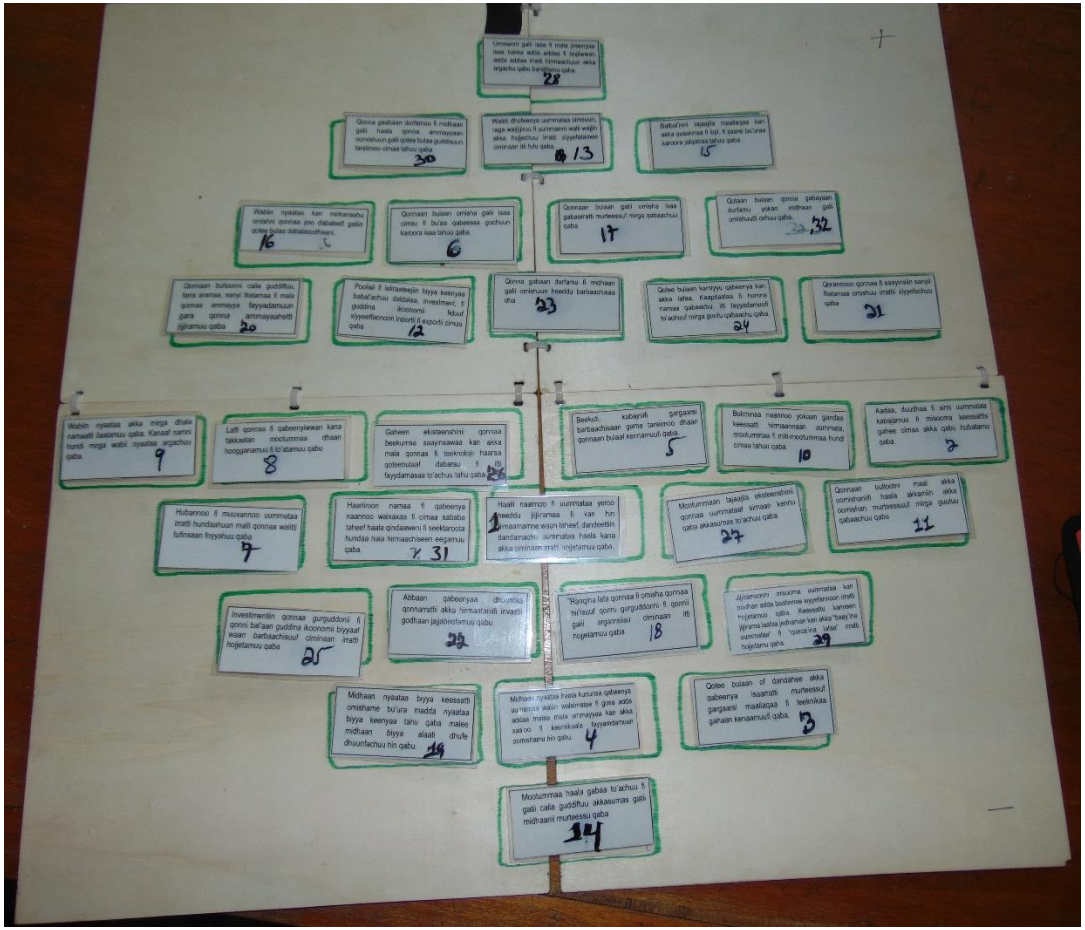

Fig. S2.1. Scoreboard used for ranking of Q-sets by the stakeholders. On the scoreboard, we drew 32 rectangles to fit the size of the Q-set cards. Their arrangement was in a quasi-normal, diamond-shaped distribution, with a scale from +4 (most important, top) to -4 (least important, bottom). Statements were laminated and attached with hook and loop fastener for easy use. The random number on the cards facilitated data recording but was not related to the content of the statements.

Chapter III

Chapter III

The governance of land use strategies: Institutional and social dimensions of land sparing and land sharing

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Conservation Letters (2017), Doi.org/10.1111/conl.12429

Landscape in Setema woreda

Abstract

Agricultural land use is a key interface between the goals of ensuring food security and protecting biodiversity. “Land sparing” supports intensive agriculture to save land for conservation, whereas “land sharing” integrates production and conservation on the same land. The framing around sparing versus sharing has been extensively debated. Here, we focused on a frequently missing yet crucial component, namely the governance dimension. Through a case-study in Ethiopia, we uncovered stakeholder preferences for sparing versus sharing, the underlying rationale, and implementation capacity challenges. Policy stakeholders preferred sparing whereas implementation stakeholders preferred sharing, which aligned with existing informal institutions. Implementation of both strategies was limited by social, biophysical, and institutional factors. Land use policies need to account for both ecological patterns and social context. The findings from simple analytical frameworks (e.g., sparing vs. sharing) therefore need to be interpreted carefully, and in a social-ecological context, to generate meaningful recommendations for conservation practice.

Keywords: Biodiversity; Conservation; Food Security; Governance; Institutions; Intensification; Land Sharing; Land Sparing; Land Use Strategy

Introduction

Improving food security and biodiversity conservation are two prominent goals for sustainability. Food security refers to the stable supply of accessible, nutritional, culturally acceptable food (FAO, 2014), while biodiversity is the variability among organisms and ecosystems (Convention on Biological Diversity, 1992). Harmonizing food security and conservation is important (Tscharntke *et al.*, 2012), but can be challenging because of pressures such as population growth, land scarcity, and climate change (Godfray *et al.*, 2012). The identification of appropriate land use strategies could be one way to facilitate improved integration of food security and conservation (Macchi, Grau, Zelaya, & Marinaro, 2013).

To this end, a prominent framework distinguishes between "land sparing" and "land sharing" (Balmford, Green, & Scharlemann, 2005; Green, Cornell, Scharlemann, & Balmford, 2005). Land sparing implies the spatial segregation of production and conservation (Fischer *et al.*, 2008; Grau, Kuemmerle, & Macchi, 2013). It is based on the recognition that agricultural area expansion is a critical threat to biodiversity (Balmford *et al.*, 2005), and therefore supports the creation of protected areas, while allowing for production zones to be intensified (Fischer *et al.*, 2008). In contrast, land sharing denotes production and conservation taking place on the same land, using biodiversity-friendly methods (Green *et al.*, 2005).

The sparing versus sharing framework has been widely used – for instance, in relation to the conservation of birds and plants (Phalan, Onial, Balmford, & Green, 2011; Egan & Mortensen, 2012), coffee management (Chandler *et al.*, 2013; Aerts *et al.*, 2017) and local livelihoods (Dressler, de Koning, Montefrio, & Firn, 2016). However, debate is ongoing about its applicability to real-world problems. Among others (Fischer *et al.*, 2014), criticisms include the possible oversimplification of complex systems, and limited consideration of social and governance dimensions, including institutions and stakeholder preferences (Chandler *et al.*, 2013; Kremen, 2015). Perhaps most importantly, the link between agricultural intensification and the creation of protected areas may be weak or absent (Phalan *et al.*, 2011; Phelps, Carrasco, Webb, Koh, & Pascual, 2013), such that agricultural intensification could even exacerbate agricultural expansion. This may occur in the case of the "Jevons paradox," where improved land use efficiency creates incentives

for the further expansion of intensive land use (Matson & Vitousek, 2006; Desquilbet, Dorin, & Couvet, 2016).

Here, we investigated governance dimensions of the sparing versus sharing framework in a multilevel governance context. We focused on southwestern Ethiopia, an internationally recognized biodiversity hotspot (Tadesse, Zavaleta, Shennan, & FitzSimmons, 2014) that has experienced major declines in forest cover (Ango, Börjeson, Senbeta, & Hylander, 2014), and has low food security by international standards (Oromia Bureau of Finance and Economic Development, 2012). Our aims were to: (1) elicit the preferences for sparing versus sharing by different stakeholders involved in food security and biodiversity conservation, from local community to national government; (2) understand the justifications for these different preferences; and (3) explore capacity limitations in the implementation of both land sparing and land sharing. We contextualize our findings by comparing them with studies from other parts of the world. We argue that social and governance dimensions should be more routinely considered in discussions about land sparing versus land sharing.

Methods

Study area

The study was conducted in Oromia regional state, Jimma zone, between October 2015 and February 2016. Ethiopia consists of nine regional states, which are demarcated on the basis of linguistics and ethnic lines (see supplementary material). The country has five administrative levels: the federal, regional, zone, woreda (district), and kebele (municipality) levels. Within Jimma zone, we selected three woredas (Gumay, Gera, and Setema), and two kebeles within each of these. The selected six kebeles (Kuda Kufi, Berwerengo, Kela Hareri, Borcho Deka, Gido Bere, Difo Mani, Fig 1.1) varied in forest cover and altitude, which are important ecological and socioeconomic drivers. We engaged with stakeholders at all five formal levels of governance

Stakeholders are organizations and community groups who affect or are affected by decisions in a specific context (Reed *et al.*, 2009). We identified relevant stakeholders– those involved in the governance of food security, biodiversity conservation, or both – through snowball sampling. We broadly conceptualized food security and involved production-related stakeholders including farmers and agricultural offices; access-related

stakeholders such as financial institutions; utilization-related stakeholders such as health offices; and stability-related stakeholders such as administration offices (Table S3.1). For biodiversity, we involved stakeholders engaged with forest, wildlife, and other biodiversity conservation aspects (Table S3.1).

We used a bottom-up process of stakeholder identification, starting with farming communities in each kebele. To avoid bias, we involved a diversity of stakeholders in terms of wealth, gender, and household location (Table S3.2). Farmers were categorized into rich versus poor, following an official wealth classification (see supplementary material).Community-level discussants were identified through the help of local guides (see supplementary material), considering their level of knowledge and experience, ability to articulate opinions, and willingness to participate.

During our work in the communities, we asked farmers to identify stakeholders they work within the context of food security or biodiversity conservation, both horizontally (i.e. within the kebele) and vertically (i.e., at higher levels). We followed this procedure to identify stakeholders up to the federal level. In total, we identified 244 stakeholders. Eighty of these were directly involved in land use policy or implementation strategies, and these form the basis for this article (Table S3.2). The remaining stakeholders were also involved in food security and/or biodiversity governance, but devising specific land use policies or implementing specific management decisions was not part of their organizational mandates (see supplementary material). For government organizations, we interviewed relevant representatives, including chairpersons, deputies, senior personnel, and technical experts.

Data collection and analysis

We collected data using semi structured interviews and (at the community level) focus group discussions. Both were guided by three themes: (1) identification of preferences concerning land use strategies (i.e., land sharing, sparing, or a combination); (2) justification of these preferences; and (3) capacity limitations for the implementation of the preferred strategy. Before the actual study, we tested and refined our questions. Because the sparing/sharing terminology was unknown to stakeholders and to ensure a common understanding, we initially explained these concepts. We described land sparing as the separation of biodiversity conservation in protected areas and intensive agricultural land use outside protected areas; whereas land sharing was described as the integration of

conservation and production on the same land. To assists take holders in understanding land sharing, we explained it using examples from the study area. First, sharing could be on the farmland, for example in the case of trees being grown in pastures or cropland. Second, sharing could also be in the forest, where traditional semi forest coffee production takes place (Aerts *et al.*, 2017, Table S3.1). Interviews and discussions lasted for approximately 1 hour, and were documented using notes and voice recordings.

For analysis, we transcribed all 80 recordings and used content analysis in the software NVivo version 11. Here, we created three separate nodes for land sparing, land sharing, and mixed strategies; classified stakeholders according to their preferences of sparing, sharing, or a combination; and identified their responsibilities in policy-making versus implementation. We then inductively created sub nodes describing arguments related to the justification of preferred strategies and capacity limitations.

Results

Aim 1: land use preferences

The preference regarding land use varied between stakeholders based on sector and wealth. Preferences included a "mixed strategy," which favored sharing and sparing within the same landscape. For example, stakeholders may have argued for using external inputs such as agrochemicals in the farmland, but also argued for the maintenance of native trees in both the forest and throughout the farmland. Both land sharing and sparing were widely supported, with land sharing preferred (40% of 80 stakeholders), followed by land sparing (34%), and a mixture of both (26%).

Three key findings emerged. First, classifying the stakeholders according to policy-making (zone, region, federal level) versus implementation levels (woreda, kebele), we found that land sharing was more popular at the implementation level, whereas land sparing and a mixture were preferred at the policy-making level. At the implementation level, 45% and 23% of stakeholders preferred land sharing and a mixed strategy, respectively (n = 62), whereas at the policy level, land sparing and mixed-land use strategies were preferred each by 39%, and land sharing was preferred by only22% (n = 18, Fig. 3.1A).

Second, stakeholders in the biodiversity sector usually preferred land sparing, whereas those in the food security sector preferred land sharing or a mixture. Of the 80 stakeholders

interviewed, 14%, 5%, and 81% were involved in the governance of food security, biodiversity, or both, respectively. We found that 43% of stakeholders involved in both sectors preferred land sharing, while 29% preferred land sparing (n = 65). All biodiversity sector stakeholders preferred land sparing (n = 4, Fig. 3.1B).

Third, a difference emerged at the community level between wealth categories. Poor community members unanimously preferred land sharing (100%, n = 11 groups of poor people). Half of the rich community stakeholders, in contrast, preferred land sparing (50%), followed by a mixed land use strategy (33%, n = 12, Fig. 3.1C).

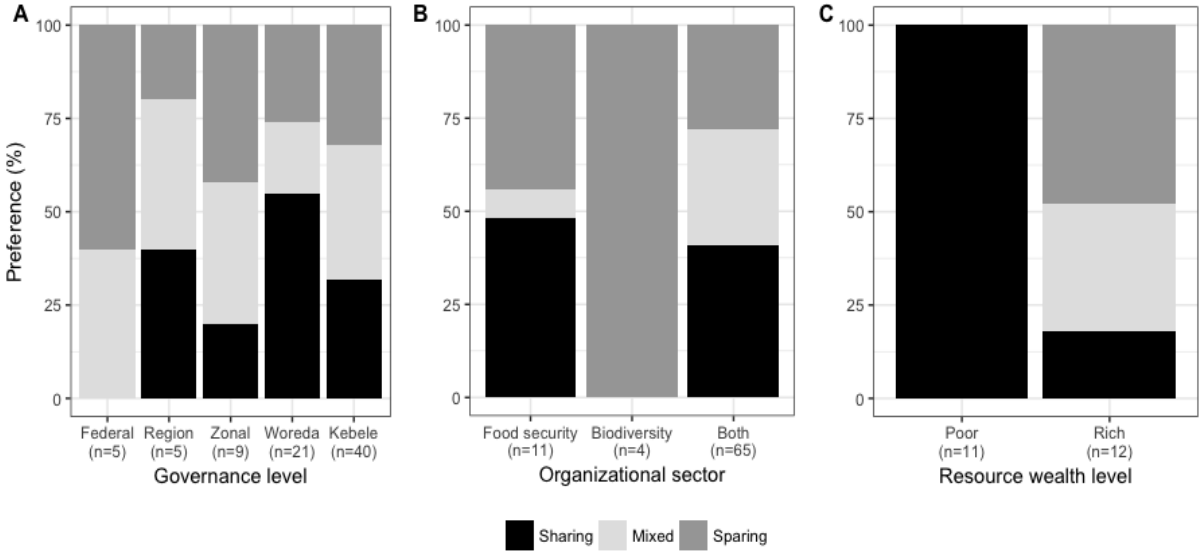

Figure 3.1. Land use preferences according to (A) level of governance, where federal to zone represents the policy-making levels and woreda and kebele represent the implementation levels; (B) stakeholders' engagement in the governance of food security, biodiversity conservation, or both sectors; and (C) the wealth category of focus groups at the community level

Aim 2: reasons underlying land use preferences

Preferences of land use strategies were determined by various factors (Table 3.1). Efficiency optimization was a prime justification for land sparing. In addition, all stakeholders with a preference for land sparing indicated that the conservation of dwindling forest biodiversity was a key motivation. Formal institutional support by the government for agricultural intensification (including access to inorganic fertilizers, pesticides, and improved seeds), and external factors such as population growth were other justifications

for land sparing. For example, an interviewee from the agricultural sector explained that "the only viable solution in the face of climate change, population increase and land degradation is to use production enhancing technologies and increase yield." An interviewee from the conservation sector stated: "Agricultural expansion and illegal settlement were primary causes of forest decline in the zone. Therefore, we [his organization] segregate agricultural land from conservation land, and demarcate [clear] conservation boundaries".

In contrast, land sharing was commonly justified through the local importance of integrated landscapes. Both local institutional support and livelihood diversification were mentioned to justify the preference for land sharing (Table 3.1). Land sharing was supported by traditions and local institutions, and was related to cultural significance, farming traditions and knowledge, and ancestral experience and valuation of nature. A focus group member exemplified this by stating that "trees such as the sycamore fig [*Ficus sycomorus*], which is rare in the forest but occurs on farmland, provide shade under which conflicts are resolved, powers are transferred, oaths are made, and traditional cultural ceremonies are undertaken. We therefore prefer a sharing approach." Cost-benefit considerations also motivated a land sharing approach (Table 3.1). Most notably, livelihood diversification– having multiple sources of income to reduce risk – was considered an advantage of integrated landscapes. A poor female discussant explained this: "We produce varieties of crops in our small plots of land because we want to diversify our meals, and reduce the burden of crop failure."

Second, high input costs explained preferences for land sharing. A focus group discussant explained: "We are forced to use fertilizer against our will. The added value to our produce through fertilizer use is lower than the cost of the fertilizer, and we have to sell assets to repay the cost of fertilizer. "Socioeconomic and biophysical landscape conditions were also considered. For instance, dispersed settlements, fragmented agricultural land holdings, and the widespread practice of shade coffee production were mentioned as reasons for preferring land sharing. The strict protection of valuable trees in the forest, while implementing land sharing within the farmland, was the primary justification of stakeholders who preferred a mixed land use strategy (n = 21).

Table 3.1. Justification given by stakeholders for their preferences of land sparing versus land sharing. The percentage indicates the proportion of stakeholders mentioned each of

the justifications in each land use category. That means, for example, all the 27 (100%) stakeholders in land sparing category mentioned that land sparing strategy is best for biodiversity conservation and protection.

Preference	Justification	(%)
Land sparing (n = 27)	Best for biodiversity conservation and protection	100
	Good to increase yields via agricultural intensification	89
	Land sparing has formal institutional support through government policy, strategy and plans	78
	There is good access to agricultural technologies for intensification	70
	There is an increase in population and demand for food	52
	There are possible gains from forest conservation through emerging carbon markets	41
	Land use specialization is better	33
	Land sharing will not work to feed the population	9
	Clear separation of land uses reduces conflict between stakeholders	8
Land sharing (n = 32)	Land sharing is consistent with traditions and local institutional support: cultural relevance, traditional farming knowledge, ancestral human-nature connections	56
	Land sharing is preferable for cost-benefit considerations: livelihood benefits of farm diversification outweigh the high costs of intensification (e.g. fertilizer)	56
	Land sharing is consistent with biophysical constraints and existing production systems: settlement structure, landscape and land ownership fragmentation, widespread shade coffee production	41
	Resource conservation: importance of sharing for the conservation of forest and farm biodiversity	31

Aim 3: capacity limitations

The implementation of land sparing was perceived to be hampered by community attributes, limited organizational capacity, and resource limitations (Table 3.2). Community attributes included reluctance to adopt agricultural technologies such as agrochemicals and improved seeds. Examples of capacity limitation were a lack of technical knowledge, inability to enforce agricultural intensification, and insufficient finances. Moreover, coordination challenges between stakeholders in food and biodiversity, or contradictory plans and activities, were mentioned as significant constraints. One government employee explained that “we distribute honey production

technologies, while the agricultural office is fostering the use of herbicides and fertilizers that harm bee colonies." Similarly, a focus group participant stated that "development agents advise us to intensify the farmland while others such as cooperatives and unions provide us with seedlings to expand farm forestry and reduce the pressure on forests."

Implementation challenges of land sharing focused chiefly on incompatibilities between community and government stakeholders. The forced imposition of agricultural technologies was perceived to impede the traditional continuation of land sharing (Table 3.2). One development agent stated that "our services are not in line with the community we ought to serve. However, we keep doing it as long as we are directed to do so from our administration."

Table 3.2. Capacity limitations for the effective implementation of preferred land use strategies as mentioned by stakeholders. The percentage in the table indicates the proportion of stakeholders mentioned each of the capacity limitations in each land use category. That means, for example, out of the 27 stakeholders in land sparing category, 21 (78%) of them described that community attributes are the main capacity limitations for the implementation of land sparing strategy.

Land use strategy	**Capacity limitations**	**(%)**
Land sparing (n = 27)	Community attributes: community is unwilling to adopt agricultural intensification	78
	Capacity limitations in implementation: lack of coordination, and contradiction of sectoral plans, strategies and activities	21
	Resource factors: limitations in skill and material limitations	18
	Conflicting interests: the interest of the government and the community are not compatible. Government services and technologies promoted are incompatible with local conditions	9
	Farming system: agricultural land holdings are small and fragmented, and "shared" forest coffee is widespread	4
	Governmental problems: There is structural fluctuation in offices and responsibilities, and administrative inconsistency between offices	3
Land Sharing (n = 32)	Imposition of technologies, strategies and plans do not match the need and capabilities of the community	14

Discussion

This study revealed previously underexplored governance challenges for the implementation of land sparing or land sharing. Although both food security and biodiversity conservation are prominent goals in our study area, we identified institutional and social challenges to their integration. As we discuss below, similar challenges are likely to apply to other smallholder farming landscapes around the world.

Preferred land use strategies differ between stakeholders

Stakeholders differed in their views how to best harmonize food security and biodiversity conservation. Importantly, preferences for land use strategies were not limited to a dichotomous distinction of strategies into "sparing" versus "sharing" but often recognized the benefits of a mixed strategy. This empirical finding is consistent with previous arguments that a combination of strategies – adjusted to local conditions – is often required (Fischer *et al.*, 2008; Kremen, 2015). It also confirms the notion that land sparing and sharing is an insufficiently nuanced framing of local realities (Kremen, 2015; Dressler *et al.*, 2016). At worst, the oversimplification of complex realities could impede rather than foster the harmonization of food production and biodiversity conservation (Butsic, Baumann, Shortland, Walker, & Kuemmerle, 2015). For instance, empirical findings by Habel *et al.* (2015) in Kenya and Law *et al.* (2015) in Indonesia indicated that land use policy involves complex and integrated decisions, highlighting that the simple implementation of either land sparing or land sharing would generate suboptimal outcomes for both food security and biodiversity conservation.

Preferences for land use strategies differed across governance levels and sectors. Locally, although there was no difference on the preference of land use strategies between the six kebeles, we found an important difference between poor and rich farmers. Poor farmers clearly preferred land sharing, whereas rich farmers – who can afford agrochemicals and may produce surplus for markets – more often favored land sparing. Whereas rich farmers may seek to maximize yields through commercialized farming, poor farmers may seek to ensure basic household needs, minimize risks, and maximize livelihood resilience against shocks. This finding is in line with research from Zimbabwe (Makate, Wang, Makate, & Mango, 2016), the Philippines (Dressler *et al.*, 2016) and India (Joshi, Gulati, & Birthal, 2007), which showed that both household wealth and perceived risk influence the land use

decisions of smallholders. Instead of imposing technocratic solutions onto complex systems, land use strategies therefore need to match local conditions. Locally appropriate options, in turn, are best explored through the involvement of multiple stakeholders and sectors. An important caveat here is that some stakeholders may prefer land sharing because they perceive this to be a win-win for food and biodiversity, when in fact, land sharing may not necessarily provide the best outcome for biodiversity conservation (Phalan *et al.*, 2011). Moreover, since we included integrated land uses in both the forest and farmland in our definition of land sharing, stakeholders may have referred to either or both of these options in our interviews.

We also revealed a disparity between policy-making and implementation-level stakeholders, with a relatively greater preference for land sparing at policy-making levels. This difference may be explained by the existing institutional context. Aspects of land sparing are enshrined in various formal institutions such as government policy, plans, and strategies (e.g. MoFED, 2010), whereas local institutions have traditionally favored land sharing. The notion of needing "more food for more people" – a common narrative in the natural sciences (Glamann, Hanspach, Abson, Collier, & Fischer, 2017) –dominates among policy-making stakeholders. However, as recognized by local stakeholders, on the ground, food security is just as much about the accessibility and distribution to the target group (Fischer *et al.*, 2014; Desquilbet *et al.*, 2016). In line with our finding, studies in India (Rai & Bawa, 2013) and Madagascar (Pirard & Belna, 2012) indicated that policy stakeholders favor land sparing because it aligns with dominant development discourses. The singular focus on production, however, is usually caused by an inadequate understanding of the complex land use dynamics and challenges experienced by local people (Mertz & Mertens, 2017). The existing discourse thus causes two main misfits: (1) an incompatibility of policies with local conditions and preferences (Leventon & Antypas, 2012) and (2) various implementation deficits created through a gap between policy content and on ground capacities (Leventon & Antypas, 2012). In a landscape with multiple functions and multiple interests, the conflict of interest between stakeholders such as between the policy and implementation-level stakeholders could be reconciled though greater use of participatory processes (Groot, 2006).For instance, in Tanzania Hart *et al.* (2014) found that community participation enhanced sustainability, empowered community, and reconciled conflict among diverse stakeholders.

In contrast to the policy scale, the choice of land sharing is often favored in a context of local experience. For instance, an empirical study in the Philippines (Dressler *et al.*, 2016) found that land sharing was supported by the local community, partly because it yielded sustainable outcomes in both social and ecological terms. Similarly, in Indonesia, Lee, Garcia-Ulloa, Ghazoul, Obidzinski, and Koh (2014) indicated that land sharing was chosen by smallholders to improve their livelihoods. In addition to ecological justifications – as stipulated by the sparing-sharing framework – social, institutional, and governance dimensions thus need to be integral parts of land use policy (Fischer *et al.*, 2014; Kremen, 2015).

Capacity limitations

Implementation challenges related to stakeholder differences, biophysical conditions, and institutional factors. For example, community members may be reluctant to intensify, stakeholders' interests may diverge, and different policies may be uncoordinated and incoherent. Existing work elsewhere suggests that such problems originate when policies are designed with minimal consideration of local context, community preferences, and capacities (Franzel & Houten, 1992); there is a lack of accommodation of diverse interests and goals (Veldhuizem*et al.*, 1997); and there is limited coordination and participation in designing, implementing, and enforcing policies(Hailemariam, 2004). To successfully design and implement suitable land use policies and strategies therefore requires the participation of a wide range of stakeholders, and needs to be compatible with the varied interests and local implementation capacities.

Conclusion

We reach three main conclusions. First, locally, the dichotomy between land sparing and sharing has limited value because existing patterns of land use are more heterogeneous. Second, agricultural landscapes are complex systems and involve stakeholders with multiple interests. The land sparing and sharing framework is grounded in ecological justifications, but on its own, does not account for social complexity. Next to ecological factors, social and institutional dimensions need to be considered in land use strategies if they are to sustainably harmonize food production and conservation goals. Third, there may be mismatches in understandings and strategic preferences between policy-making stakeholders and formal institutions versus implementing stakeholders and informal

institutions. To minimize such mismatches, land use policies should ensure stakeholder participation (both during policy design and implementation) and coordination between sectors (both at policy and implementation levels).

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Supplementary material

Study area

Ethiopia has a federal government consisting of nine regional states and two city administrations, which are demarcated on the basis of linguistics and ethnic lines. As stipulated in the Ethiopian constitution Article 46, sub-Article 2, states are delimited based on settlement pattern, linguistics, ethnic identity and the consent of the peoples concerned. The administration of the country has five tiers: the national/federal level, regional states, zonal administration, district (hereafter woreda) administration and kebeles (the lowest administrative unit). Oromia region, home of the Oromo ethnic group, is the largest state in terms of population and area covered. Administratively, the region is classified into 18 zonal administrations. This study was conducted in the Jimma zone in Oromia regional state, southwestern Ethiopia (Fig. 1.1). The zone is located approximately 350 km southwest of the national and Oromia regional capital, Addis Ababa. Jimma zone constitutes 18 woredas and 513 kebeles. The total population of Jimma zone is estimated to be 3.14 million people (OBFED, 2012). Approximately 95% of the population of Jimma zone resides in rural areas (OBFED, 2012). Jimma zone is a center of origin for coffee (*Coffea arabica*). According to the Jimma Zone Bureau of Agriculture, Jimma zone accounts for 70% of the total coffee produced in the country (unpublished 2008 report).

Research design

We selected our study area because it has rich but declining biodiversity (Ango et al. 2014). People in Jimma zone are relatively better off in terms of food security than in the drier parts of Ethiopia, but many inhabitants remain food insecure by international standards – seasonal food shortages, where meals need to be skipped or reduced, are common (WFP, 2014). Within Jimma zone, we focused on three woredas, namely Gumay, Gera, and Setema (see Fig. 1.1). Similarly, six kebeles (two in each woreda) were selected to cover gradients of forest cover, coffee production, and food security in the area. Therefore, for our governance analysis, we considered stakeholders from six kebeles, three woredas, as well as zonal, regional and national governance levels.

Stakeholders working on food security or biodiversity conservation (or both) were identified through bottom-up snowball sampling starting at the kebele (most local) level, to ensure that no important stakeholders were missed. First, kebele level stakeholders,

including local community and on-ground development and conservation stakeholders, were identified through the help of local guides and administrators, to whom we had explained the scope and goal of the project. Accordingly, groups of farmers were identified and categorized into rich versus poor, drawing on taxation data from local government offices. The classification of wealth into two wealth classes was based on household assets such as land holdings, annual income and food security status. This categorization was used to explore differences in the preference of land use strategies between wealth categories. After this classification, key informant interviewees and focus group discussants were identified through the help of local guides – including kebele level agricultural development agents, health development agents, kebele leaders, and community group leaders. We used a set of pre-defined criteria in the selection of respondents to ensure both social as well as geographical representativeness, and to minimize the potential bias caused due to social and geographic factors. Thus, we considered respondents' willingness and ability to discuss, and level of knowledge of food and biodiversity issues through their experience in the area. The level of formal education within the community was similar among wealthy and poor people, and we avoided the possibility of elite capture by separately interviewing different status groups and a diversity of respondents. For instance, within every kebele, there were three community groups composed of inhabitants who were clustered based on their geographical settlement in the kebele.

In both focus group discussions and key informant interviews, all kebele level stakeholders (community as well as other governmental and non-governmental organizations) were asked about five general themes: (1) General background and trends in land use in the area; (2) land use preferences; (3) justification for the preference; (4) challenges for the implementation of the preferred land use system; and (5) other stakeholders involved in the governance of food security and biodiversity, both horizontally (i.e. within the kebele) and vertically (i.e. at higher governance levels).

Drawing on information gathered from the fifth question listed above, we considered all stakeholders involved in the production and supply, access, utilization and agency dimensions of food security, as well as farm and forest dimensions of biodiversity management (see Table S1 for explanations of concepts). Based on this process at the kebele level, we identified woreda level stakeholders, and continued this process up to the national level, until no new stakeholders were mentioned. This process of stakeholder

identification generated 244 stakeholders in the governance of food security and biodiversity from local up to the national/federal level. However, because food security and biodiversity governance are broader concepts than just land governance, only 80 of the 244 stakeholders were directly involved in the decision related to land use. Some of the stakeholders, for instance credit and finance associations (OCSA) and youth and sports office (YOSP), were part of food security governance but were not involved in land use decisions. Thus, we considered only those 80 stakeholders directly involved with land governance in this study (Table S3.2). We administered interviews with stakeholders through their respective representatives, which included heads or deputies of the organization, planning officers, and senior personnel.

The process of data collection took two steps. First, we pre-tested the data collection tools in August 2015 to see whether the prepared protocol would be properly understood and generate the intended data. We then modified the tools accordingly based on the field trial. Second, we conducted the actual data collection between October-February 2015-2016. Because the terminology and concept of "land sparing" versus "land sharing" was unknown to stakeholders, we explained these concepts to all stakeholders before we commenced the interview. We described land sparing as a strategy that is a spatial segregation of agricultural land and biodiversity conservation areas whereas land sharing was described as a strategy that attempts to integrate conservation and production on the same land (see Table S3.1 for details). We audio recorded and took notes of all the interviews and discussions after obtaining voluntary, informed consent by the stakeholders.

For analysis, we translated and transcribed all the 80 recordings and field notes separately for each of the stakeholders. Following this, we used NVivo software version 11 to code and analyze the data. In NVivo, we deductively created three separate nodes for land sparing, land sharing and mixed strategies; and classified stakeholders according to their preferences of sparing, sharing or a mix; and identified their responsibilities in policy-making versus implementation. We then inductively created sub-nodes under each of the categories and coded arguments or justifications provided by the stakeholders for their preferred land use strategy. Similarly, we created sub-nodes for the capacity limitations for each of the three categories and coded stakeholder's response. Finally, the coded data were categorized and themes emerging were analyzed using content analysis.

Concepts used in the paper

Table S3.1: Meaning of concepts as it is used in the paper

Concept	Description
Food security	Food security is a broad concept that has multiple definitions (see Maxwell and Smith, et al. 1992). Here, we adopted the definition provided by world food program: "Food security exists when all people have physical, social and economic access to sufficient, safe, nutritious and preferred food at all times, such that they can lead a healthy and productive life" (FAO, 2014). This conceptualization of food security entails four major dimensions of food security: 1) Availability/ production dimension: this dimension involves ensuring that food is sufficiently available to all people at all times. Accordingly, stakeholders involved in the food production sector were considered in our assessment of land use preference; 2) Economic and physical access: this dimension comprises ensuring that all people have the physical and financial capacity to afford nutritious and preferred food. Thus, stakeholders mandated with financial and capacity empowerment of the community were considered in scoping this study; 3) Utilization dimension: this dimension focuses on the adequacy and nutritional values of food consumed and hence involves stakeholders from health and other dietary service providers whom were also part of this study. 4) Stability dimension: this component of food security is concerned with the uninterrupted functioning of the above dimensions, and hence involves institutions such as administration, regulatory and monitoring agencies. These stakeholders were also part of this study. Thus, at first, all stakeholders involved in these dimensions were considered. From these stakeholders, however, those who were directly related with the land use governance were considered in the interviews and focus group discussions that were the specific purpose of this paper.
Biodiversity	Biodiversity is another broad concept used in this paper. For this paper, we adopted the definition of biodiversity as provided by Convention on Biological Diversity (CBD, 1992) which stated biodiversity as: "the

variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems" (CBD, 1992). We considered all stakeholders involved in the governance of biodiversity for both farmland and forest land. After this broad framing, we identified those stakeholders who had a direct stake in land governance.

Land sparing

Land sparing describes a spatial segregation of areas used for intensive farming and areas strictly protected for biodiversity conservation. It is a land use strategy that supports the segregation and strict conservation of biodiversity through creation of protected areas along with agricultural land intensification through extensive use of external inputs such as agrochemicals to compensate the land spared for biodiversity conservation.

Land sharing

Broadly, land sharing indicates a strategy that combines food production and biodiversity conservation on the same land thus providing lower levels of protection but also lower amounts of external inputs. Land sharing is conceptualized in different ways based on the context. For instance, it could mean using agricultural practices that support biodiverse and heterogeneous agricultural systems that may or may not include forest fragments. It could also mean retaining forest in the traditional agricultural land use system. The proxy used in framing land sharing varies mainly depending on agricultural yield level, agricultural practices or heterogeneity of agricultural landscape (see Kremen, 2015). To avoid the ambiguity associated with the concept, we made explicit to all stakeholders that land sharing involves the two conditions of traditional low external input agricultural farming with farm heterogeneity. This could happen both on farmland as well as on forest land. For instance, producing coffee in the forest is a common practice of the landscape in the study area. Similarly, trees on farmland as patches or scattered trees are common in the landscape. Hence, in our case, we conceptualized land sharing as a practice of maintaining trees on farmland with low agricultural intensification and producing coffee in the shade of forest land.

Mixed land use system	A mixed land use strategy combines elements of both the land sharing and land sparing strategies in a mosaic of different land use types. The concept is similar with what Kremen (2015) emphasized in her paper as "Both-and" type of land use policy options. We considered a mixed land use system when the stakeholders preferred to see both land sharing and land sparing on the same land use system. For instance, some stakeholders preferred the use of external inputs such as agrochemicals while maintaining trees and patches of forest on the farm land, or the use of traditional agricultural farming with less applications of agrochemicals on the farm land, and still sparing the conservation land as a protected area.
Agricultural intensification	We considered this to be an agricultural practice to raise yield output per unit land area. The increase in yield per unit area could be achieved either through *conventional intensification* which support the intensive use of irrigation and agrochemicals, high-yielding crop, and farm mechanization. An alternative type of intensification is *agro-ecological intensification* which supports agricultural yield increase through natural means such as using agroforestry techniques (see Loos et al. 2014)

List of stakeholders

Table S3.2. A list of all stakeholders and their abbreviations. The first column gives the stakeholder's acronym while the full name of the actor is given in the second column. The third and fourth columns indicate stakeholders' administrative levels and the name of the corresponding administrative level. The fifth column shows the type of organization including CG (community groups); GO (governmental organizations); FR (farmers); CA (semi-autonomous cooperative agency) and NGO (non-governmental organizations). The last column indicates the gender characteristics of participants as M (male respondents or discussants) and F (female respondents or discussants).

Actors acronym	**Full name of stakeholders**	**Administrative Level**	**Administrative name**	**Type of organization**	**Gender**	
					M	**F**
PoK1	Poor community group	Kebele	Kuda Kufi (KK)	CG	4	3
PoK2	Poor community representative	Kebele	Kuda Kufi (KK)	FR		1
RiK1	Rich community groups	Kebele	Kuda Kufi (KK)	CG	3	3
RiK2	Rich community respondent	Kebele	Kuda Kufi (KK)	FR	1	
GeK	General community	Kebele	Kuda Kufi (KK)	CG	4	3
NeK	Community network leaders	Kebele	Kuda Kufi (KK)	CG	3	
LeK	Kebele leaders	Kebele	Kuda Kufi (KK)	GO	1	
CoPK	Jawi multipurpose cooperative	Kebele	Kuda Kufi (KK)	CG	1	
PoB1	Poor community group	Kebele	Kuda Kufi (KK)	CG	2	4
PoB2	Poor community representative	Kebele	Kuda Kufi (KK)	FR		1
RiB	Rich community groups	Kebele	Berwerengo (BW)	CG	5	
RiB2	Rich community representative	Kebele	Berwerengo (BW)	FR	1	

GeB	General community	Kebele	Berwerengo (BW)	CG	3	2
NeB	Community network leaders	Kebele	Berwerengo (BW)	CG	3	
PoD1	Poor community group	Kebele	Difo Mani (DM)	CG	4	4
PoD2	Poor community representative	Kebele	Difo Mani (DM)	FR	1	
RiD1	Rich community group	Kebele	Difo Mani (DM)	CG	5	2
RiD2	Rich community representative	Kebele	Difo Mani (DM)	FR	1	
GeD	General community	Kebele	Difo Mani (DM)	CG	3	2
HeD	Health extension office	Kebele	Difo Mani (DM)	GO		1
DaD	Development agent/agricultural extension office	Kebele	Difo Mani (DM)	GO	1	
PoG	Poor community group	Kebele	Gido Bere (GB)	CG	3	2
RiG	Rich community group	Kebele	Gido Bere (GB)	CG	2	2
RiG2	Rich community representative	Kebele	Gido Bere (GB)	FR	1	
GeG	General community	Kebele	Gido Bere (GB)	CG	5	2
DaG	Development agent/agricultural extension office	Kebele	Gido Bere (GB)	GO	2	
PoK1	Poor community group	Kebele	Kela Hareri (KH)	CG	3	3
PoK2	Poor community representative	Kebele	Kela Hareri (KH)	FR	1	
Rik1	Rich community group	Kebele	Kela Hareri (KH)	CG	3	3
Rik2	Rich community representative	Kebele	Kela Hareri (KH)	FR	1	

GeK1	General community	Kebele	Kela Hareri (KH)	CG	5	2
NeK1	Community network leaders	Kebele	Kela Hareri (KH)	CG	3	
LeK1	Kebele leaders	Kebele	Kela Hareri (KH)	GO	1	
PoB1	Poor community group	Kebele	Borcho Deka (BD)	CG	4	3
PoB2	Poor community representative	Kebele	Borcho Deka (BD)	FR		1
RiB1	Rich community group	Kebele	Borcho Deka (BD)	CG	3	3
RiB2	Rich community representative	Kebele	Borcho Deka (BD)	FR	1	
GeB1	General community	Kebele	Borcho Deka (BD)	CG	6	3
LeB1	Kebele leaders	Kebele	Borcho Deka (BD)	GO	1	
DaB1	Development agent/agricultural extension office	Kebele	Borcho Deka (BD)	GO	1	
BOAGU	Bureau of agriculture and natural resources office	Woreda	Gumay (GM)	GO	1	
LAEMGU	Land administration and environmental management	Woreda	Gumay (GM)	GO	1	
IRRGU	Irrigation development authority office	Woreda	Gumay (GM)	GO	1	
DPPGU	Disaster prevention and preparedness office	Woreda	Gumay (GM)	GO	1	
COPGU	Cooperative development office	Woreda	Gumay (GM)	GO	1	
OFWEGU	Oromia forest and wildlife enterprise office	Woreda	Gumay (GM)	GO	1	

TAMDGU	Trade and market development office	Woreda	Gumay (GM)	GO	1	
BOAGE	Bureau of agriculture and natural resources	Woreda	Gera (GE)	GO	1	
IRRGE	Irrigation development authority office	Woreda	Gera (GE)	GO	1	
LIVGE	Livestock and fisheries development and marketing	Woreda	Gera (GE)	GO	1	
COPGE	Cooperative development office	Woreda	Gera (GE)	GO		1
LAEMGE	Land administration and environmental management	Woreda	Gera (GE)	GO	1	
MEIGE	Micro finance enterprise office	Woreda	Gera (GE)	GO	1	
BOASE	Bureau of agriculture and natural resources	Woreda	Setema (SE)	GO	1	
LAEMSE	Land administration and environmental management	Woreda	Setema (SE)	GO	1	
IRRSE	Irrigation development authority office	Woreda	Setema (SE)	GO	1	
LIVSE	Livestock and fisheries development and marketing	Woreda	Setema (SE)	GO	1	
COPSE	Cooperative development office	Woreda	Setema (SE)	GO		1
TAMDSE	Trade and market development office	Woreda	Setema (SE)	GO	1	
DPPSE	Disaster prevention and preparedness office	Woreda	Setema (SE)	GO	1	

OFWESE	Oromia forest and wildlife enterprise office	Woreda	Setema (SE)	GO	1	
BOAJZ	Bureau of agriculture and natural resources	Zone	Jimma (JI)	GO	1	
IRRJZ	Irrigation development authority office	Zone	Jimma (JI)	GO	1	
LAEMJZ	Land administration and environmental management	Zone	Jimma (JI)	GO	1	
CASCAJZ	Capacity building for scaling up best practices project	Zone	Jimma (JI)	NGO	3	
EARIJZ	Ethiopian agricultural research institute	Zone	Jimma (JI)	GO	1	1
AMEJZ	Agricultural mechanization research center	Zone	Jimma (JI)	GO	1	
OFWEJZ	Oromia forest and wildlife enterprise	Zone	Jimma (JI)	GO	1	
IBC	Institute of biodiversity conservation	Zone	Jimma (JI)	GO	1	1
AGPJZ	Agricultural growth program office	Zone	Jimma (JI)	NGO	1	
IRROR	Irrigation development authority office	Region	Oromia (OR)	GO	1	
COPOR	Cooperative development office	Region	Oromia (OR)	GO	1	
DPPCOR	Disaster prevention and preparedness office	Region	Oromia (OR)	GO	1	
OCA	Oromia cooperative agency office	Region	Oromia (OR)	CA	1	
BOA	Bureau of agriculture and natural resources	Region	Oromia (OR)	GO	1	

MOA	Ministry of agriculture and natural resources	Federal	Ethiopia (ET)	GO	1
MOL	Ministry of livestock development and fisheries	Federal	Ethiopia (ET)	GO	1
IBD	Ethiopian biodiversity institute	Federal	Ethiopia (ET)	GO	1
MOFECC	Ministry of environment, forest and climate change	Federal	Ethiopia (ET)	GO	1
EWCA	Ethiopian wildlife conservation authority	Federal	Ethiopia (ET)	GO	1

Section B: The governance structures and processes

This section examines the structural and process governance properties that facilitate or hamper food security and biodiversity conservation. Chapter IV investigate stakeholder interaction in the governance of food security and biodiversity conservation through mapping stakeholder social network. This chapter measure structural mechanisms of food security and biodiversity integration. Chapter V Chapter V elicited governance process challenges in relation achieving each goals, i.e. in only biodiversity or food security, and their integration, using qualitative content analysis of data obtained from each of 201 stakeholders in a multi-level governance context of southwestern Ethiopia.

Chapter IV

Chapter IV

Integrating food security and biodiversity governance: A multi-level social network analysis in Ethiopia

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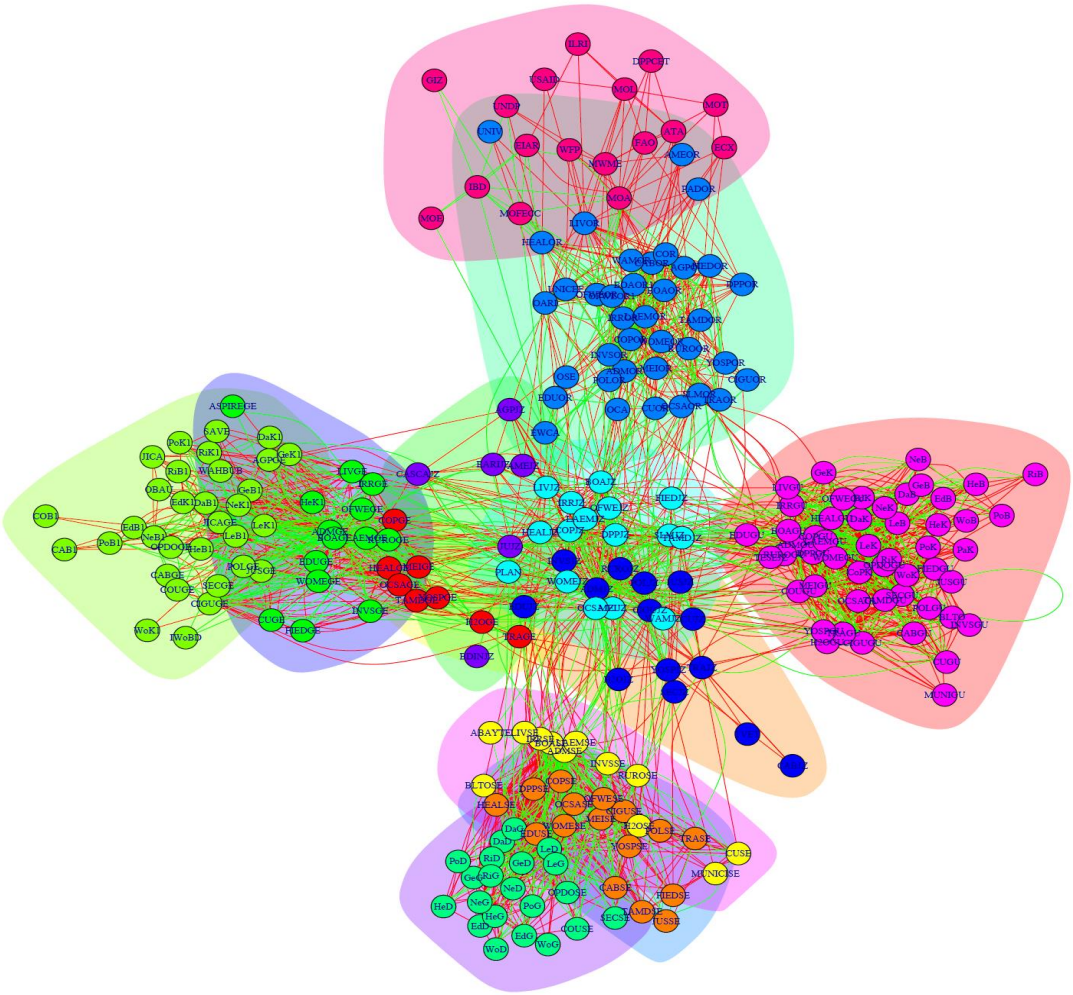


Stakeholders social network around food security and biodiversity conservation in Ethiopia

Abstract

Integrating food security and biodiversity conservation is an important contemporary challenge. Traditionally, food security and biodiversity conservation have been considered as separate or even incompatible policy goals. However, there is growing recognition of their interdependence, as well as of the need to coordinate solutions across multiple policy sectors and levels of governance. Despite such recognition, there has been no empirical analysis of governance networks that specifically integrates food security and biodiversity. Focusing on southwestern Ethiopia, this paper used social network analysis to investigate three main questions: how stakeholders interact in the governance of food security and biodiversity in a multi-level governance context; how the goals of food security and biodiversity are integrated in such a multi-level governance context; and which stakeholders are popular and play connecting roles between stakeholders in the governance network. The study was conducted in a subsistence dominated farming landscape, where we interviewed 244 stakeholders ranging from local to national levels. We found that the governance of food security and biodiversity conservation was strongly hierarchical, with virtually no horizontal linkages between adjacent districts, and very few vertical direct interactions of stakeholders spanning two or more levels of governance. Introducing a novel analytical distinction of collaborative vs individual integration, we found that only a minority of the collaborations between stakeholders took both food security and biodiversity into account, despite the majority of actors being individually involved in both sectors. Stakeholders with positional power, sociological power (popularity) and formal authority played a liaison role in the governance network. To further improve integration of food security and biodiversity conservation, a governance network that harnesses stakeholder collaboration across sectors and governance levels is essential. However, given the central role of many government administrative organizations, possible problems of power capture by some stakeholders need to be carefully managed.

Keywords: Biodiversity, Food Security, Governance, Harmonization, Integration, Multi-Level Governance, Social Network Analysis, Stakeholders, Stakeholder Analysis, Collaborative Governance.

Introduction

Ensuring universal food security and halting biodiversity decline are two of the biggest contemporary global governance challenges. Food security exists when all people have access to sufficient, safe, nutritious and preferred food, such that they can lead a healthy and productive life (FAO, 2014). Biodiversity refers to the variability among living organisms including diversity in genes, species, and ecosystems (Convention on Biological Diversity, 1992). Agricultural production – one aspect of food security – poses a threat to biodiversity through agricultural area expansion (Balmford et al., 2005; Smith, 2013), and agricultural intensification (Pimentel et al., 2005). Loss of biodiversity, in turn, may have negative short-term and long-term effects on agricultural production and thus also on food security (Sunderland, 2011; UNEP, 2013).

Historically, food security and biodiversity conservation have been governed separately (Sunderland, 2011; Chitakira et al., 2012). More recently, with the introduction of the Sustainable Development Goals (SDGs), there has been increased recognition that the integration of food security and biodiversity conservation is necessary to ensure sustainable outcomes in both (Brussaard et al., 2010; Chappell and LaValle, 2011; Mark et al., 2017). With the aim of managing trade-offs and ensuring a synergistic outcome, programs around the implementation of the SDGs seek to integrate social, economic and environmental aspects. One way to harmoniously achieve these goals is to foster a governance network that enhances integration of multiple sectors and stakeholders across different governance levels (Mark et al., 2017), as well as a coordinated policy process and coherent policy goals (Tosun and Leininger, 2017). Here, a key goal is to minimize possible trade-offs between food production and conservation, and maximize synergies through appropriate governance (Carlsson and Sandström, 2007; Tscharntke et al., 2012).

Governance comprises both the structures (actors and their linkages) and processes (rule making and enforcement process) influencing food security and biodiversity conservation outcomes (Hill, 2013; Mertens et al., 2015). Governance structures reflect how different stakeholders are arranged or the structural pattern of relation between stakeholders to bring about certain outcomes (Bodin and Crona, 2009). In social-ecological systems governance, structure could range from a strictly hierarchical – a top-down or a bottom-up governance structure – to a governance network – that is, a structure that supports stakeholder

interaction across multiple geographical jurisdictions, policy sectors and governance levels (Cumming 2016).

The focus of this paper is on the governance network influencing food security and biodiversity conservation, that is, on the interactions between agencies and other stakeholders from various districts and governance levels through which decisions are made and actions are taken that affect food security, biodiversity or both (Alexander et al. 2016). A stakeholder, in this context, is any actor who affects or is affected by a decision, including government agencies, community groups, and non-governmental organizations with diverse interests, positions and power (Freeman, 1978; Lemos and Agrawal, 2006). Understanding the pattern of interactions among stakeholders is crucial for governance in any context, but especially when there are multiple objectives across different domains such as in the context of food security and biodiversity conservation. Despite abundant literature on the governance of food security as well as biodiversity, to the best of our knowledge, no study has specifically addressed how existing governance arrangements help or hinder the integration and harmonization of food security and biodiversity. This is a major shortcoming because many developing countries are both highly biodiverse and food insecure.

To harmonize food security and biodiversity conservation, understanding the governance network is important because structural linkages between actors lay the foundation for how different interests, policies and strategies are integrated and implemented. For example, collective action, integration of diverse interests, learning and sharing of experience, effective interaction of stakeholders across governance levels, and appropriate implementation can all be fostered or hindered by the established governance structure (Leventon and Antypas, 2012; Berkes and Ross, 2013; Cumming, 2016). The nexus between food security and biodiversity is part of a social-ecological system that is characterized by complexity, interconnectedness and dynamism (Berkes et al., 2003; Folke, 2016). For such complex systems, it is widely agreed that the governance network should involve different stakeholders in decision-making, promote collaboration across governance levels, and foster horizontal interaction among actors (Berkes et al., 2003; Bodin and Crona, 2009; Bodin, 2017). Related to this is the notion of collaborative governance, which describes a governance network where multiple stakeholders involving public, non-governmental and civil society collaborate and interact, across geographical

and jurisdictional boundaries, governance scales, levels and units (Emerson et al., 2012; Bodin et al., 2017). Although there is no governance panacea (Ostrom, 2007), collaborative governance is likely to be more effective in complex systems than a strictly hierarchical, linear governance structure (Bunderson et al., 2016), which may be more efficient for more clearly defined problems associated with broader consensus (Cumming, 2016; Bodin, 2017). A collaborative governance network is recommended for complex social-ecological systems since it is flexible, inclusive and adaptive and facilitates learning (Bodin, 2017). Nevertheless, collaborative governance network can also generate conflict, delay action, or may be used by influential stakeholders to collaborate purely to pursue their own interests (Koontz and Thomas, 2006; Cumming, 2016). Furthermore, we must remain critical of where in a governance network collaboration occurs; it is possible that the stakeholders that are tasked with bringing together diverse interests may not have the capacities or powers to do so effectively (Leventon and Antypas, 2012). Thus, to assess the effectiveness of a governance network one must investigate the characteristics of stakeholders, the position and interest of individual stakeholders in the collaborative network, and the nature of collaboration between the stakeholders (Bodin and Norberg, 2007; Cumming, 2016; Bodin, 2017). One suitable method to study the different types of collaborative governance network – including in the integration of food security and biodiversity conservation – is social network analysis (Bodin and Crona, 2009).

Governance of multiple policy domains can be integrated in various ways. To distinguish how different integration processes may relate to the governance network, we introduce a new conceptual distinction of 'collaborative' versus 'individual' governance integration, which we analyze using network analysis. We define individual integration as when a stakeholder collaborates on food security with one partner, and on biodiversity with another partner. Collaborative integration, on the other hand, occurs when two stakeholders integrate both policy goals in a single collaboration. The individual integration approach may help an individual stakeholder to harmonize the two policy goals in its individual governance activities, for example by learning from different collaborations. However, the individual approach to integration cannot guarantee that integration will improve at the system level, since each stakeholder deals with the two policy goals separately, and with different partners. In addition, it can increase misunderstanding between stakeholders, hamper system level coordination, create institutional misfits and hamper broader goal attainment at a system level. In contrast, collaborative integration is a more direct approach

to integration and thus more likely to improve integration at a system level, since it means that two stakeholders are in position to simultaneously discuss potential conflicts and synergies between the two goals.

Possible synergies and trade-offs between food security and biodiversity conservation play out most prominently in smallholder-dominated rural landscapes, which play a major role in global food security (Graeub et al., 2016). We applied social network analysis to study the governance structures affecting food security and biodiversity in a rural landscape of southwestern Ethiopia. The landscape is part of an internationally recognized biodiversity hotspot, but biodiversity is under pressure from forest clearing (Aerts et al., 2017; Gove et al., 2008), agricultural intensification (Eshete, 2013), and population growth (Oromia Bureau of Finance and Economic Development, 2012). Food security in southwestern Ethiopia is relatively high by national standards, but very low by international comparisons. Given the simultaneous and interconnected challenges related to food security and biodiversity conservation in this system, the integrated governance of food security and biodiversity conservation is particularly important. Our study aimed to: (1) identify and map the interactions (including individual and collaborative integration) of stakeholders involved in food security and biodiversity conservation in a multi-level governance context; (2) examine how food security and biodiversity goals are integrated at the stakeholder and system levels, respectively; and (3) identify and characterize key stakeholders who play connecting (linking) roles between different stakeholders, and those who are otherwise particularly prominent in the governance of food security and biodiversity. Connecting stakeholders are those who are structurally positioned to connect or bridge between different stakeholders or groups of stakeholders, whereas irrespective of their structural position, prominent stakeholders are those stakeholders ranked as most important by other stakeholders. Prominent stakeholders, although structurally not necessarily found between other stakeholders, still play an important role in ensuring food security and biodiversity.

Methodology

Study area

The study was done in the Jimma zone of Oromia regional state, southwestern Ethiopia (Fig. 4.1). Ethiopia has a federal government consisting of nine regional states and two city administrations, which are demarcated on the basis of linguistics. The administration of the

country has five tiers: the national or federal level, regional states, zones, districts or hereafter "woredas", and municipalities or hereafter "kebeles". Oromia regional state consists of 18 zones. Jimma zone is located approximately 350 km southwest of the national and Oromia regional capital, Addis Ababa. Jimma zone contains 18 woredas and 513 kebeles (Facts of Oromia Region, 2012). The total population of Jimma zone is approximately 3.1 million people, accounting for just under 10% of Oromia's population, but covering only approximately 5% of Oromia's land (Oromia Bureau of Finance and Economic Development, 2012). Smallholder agriculture is the most common livelihood, with smallholder farmers accounting for 89 % of the population. Cereals and pulses are the dominant food crops, whereas coffee production is the primary source of household income. Jimma zone is considered food secure in comparison with other parts of the country (Facts of Oromia region, 2012), but remains food insecure by international standards (CSA/WFP, 2014). Jimma zone is rich in biodiversity and approximately half of its land is covered by forest. Although Jimma zone is demarcated as a regional forest priority area, biodiversity is declining due to various anthropogenic factors, including the expansion of agricultural land (Oromia Bureau of Finance and Economic Development, 2012).

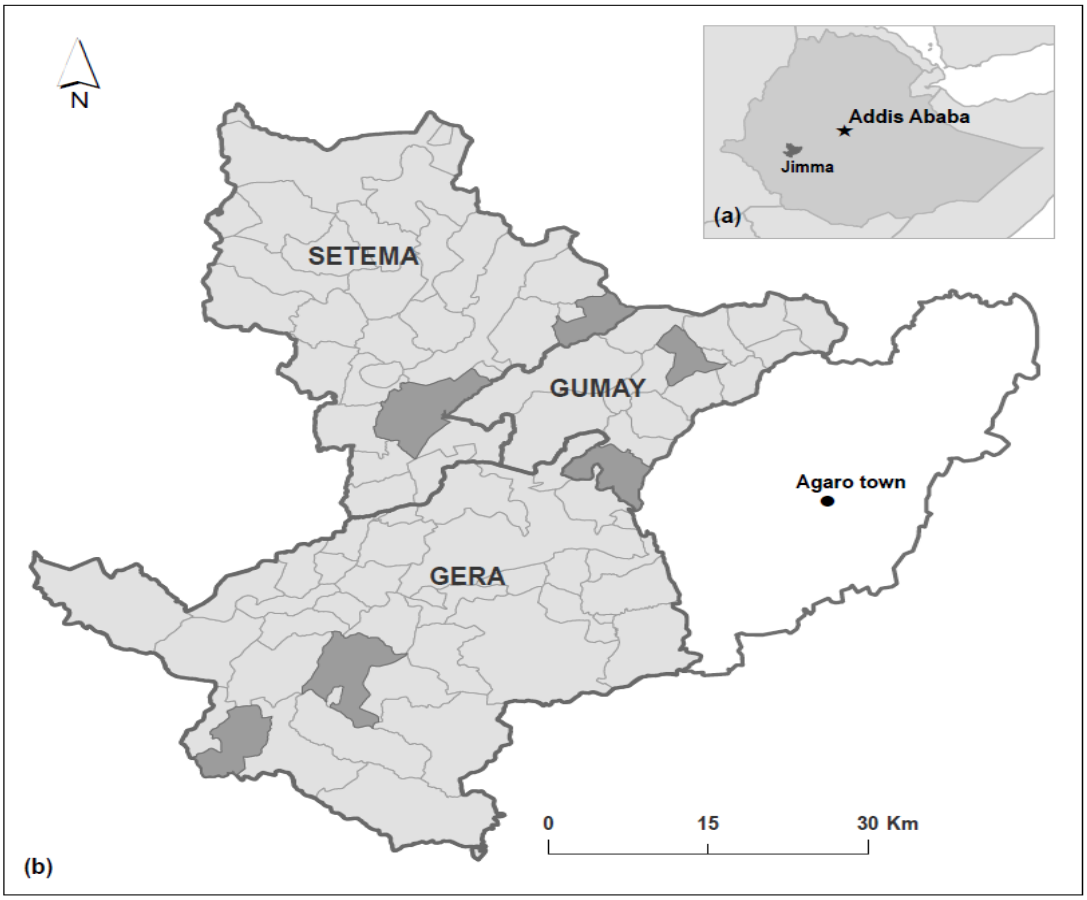


Fig 4.1. (a) The study area in south-western Ethiopia. Jimma zone, the study location is indicated as the dark area on the Ethiopian map. **(b)** The three study woredas Setema, Gumay and Gera. The six kebeles chosen for this study are shaded (Gido Bari, Difo Mani, Kuda Kufi, Bereha Werango, Kella Hareri, and Borcho Deka). The 24 community group interview were conducted in these kebeles; which were purposively selected to cover a range of social and biophysical conditions within the study area.

Our study was part of a larger, interdisciplinary investigation involving both the social and ecological dimensions of food security and biodiversity, and the study area of this larger project was selected because of the strong interaction of food security and biodiversity (Ango et al., 2014). Thus, Jimma zone was selected to cover relevant social and ecological variation of the landscape. Within Jimma zone, we focused on three woredas, namely Gumay, Gera, and Setema (Fig. 4.1). These three woredas were selected in order to cover a variation in the social and ecological variables that were expected to have the largest influence on food security and biodiversity in the study area. We specifically considered to cover social-ecological gradients involving different altitudes (e.g. within and above coffee

growing altitude); farming system characteristics of the woredas (e.g. dominance of coffee or cereal production); forest condition (e.g. Gera woreda has the largest and densest forests); livelihood conditions of the people; and infrastructure and service availability (e.g. Gumay is close to a big town with greater access to social services). Regarding population density and land area, the three woredas are all broadly representative of average conditions within Jimma zone (Oromia Bureau of Finance and Economic Development, 2012). Finally, for the sake of logistic feasibility, we selected woredas that were adjacent to one another. Within the woredas, a total of six (non-adjacent) kebeles were selected to cover gradients of forest cover, coffee production, and food security in the area. Our social network analysis thus considered six kebeles, three woredas, zonal, regional and national levels of administration.

Research design and data collection

A mixed methods approach, drawing on quantitative and qualitative data, was used to generate the social network data. Our focus was primarily on structural aspects of governance, so we focused primarily on the quantitative data to visualize stakeholder interactions, and characterize the nature, type, frequency and strength of their interactions. Qualitative methods were used to complement our understanding of the network structure, for example to understand the roles of different stakeholders. Across all governance levels – from local to national – we sought to identify all important stakeholders involved in food security and biodiversity governance, and map their interactions.

Stakeholders were identified through bottom-up snowball sampling starting at the kebele level. Snowball sampling usually starts from specific predefined stakeholders, levels or categories of stakeholders (Leventon et al., 2016; Reed et al., 2009). Here, kebele level stakeholders, including local communities, were identified through the help of local guides and administrators, to whom we had explained the scope of the project. We considered all stakeholders involved in the production and supply, access, utilization and agency dimensions of food security, as well as farm and forest dimensions of biodiversity management. All kebele level stakeholders were asked to mention other stakeholders involved in the governance of food security and biodiversity, both horizontally (i.e. within the kebele) and vertically (i.e. at higher governance levels).

Based on this, we identified woreda level stakeholders, and continued this process up to the national level, until no new stakeholders were mentioned. Individuals in key positions such as heads and deputy heads of organizations, planners and experts whom we interviewed, were considered to represent the selected stakeholder organization. In total, we identified 244 stakeholders and conducted interviews with 232 (95%) of them. Twenty-four of these stakeholder interviews were directed at community groups (four per kebele), consisting of all segments of the community including a poor community group, a wealthy community group, and community "network" representatives (a local institution comprising multiple households).

In each case, we asked interviewees to explain how their organization (or community group) was involved in the governance of food security and/or biodiversity. We characterized each stakeholder based on its primary interest being in food security and/or biodiversity. We then asked stakeholders to first list all partners with whom they interact concerning food security governance; and then all partners with whom they interact for biodiversity governance. This process generated a social network in which 244 stakeholders were interconnected by two types of links, one representing interactions in food security governance (hereafter called "food links"), and the other type representing interactions in biodiversity governance (hereafter called "biodiversity links"). Furthermore, each link was classified by the respondent as "administrative" (for formal administrative matters), "functional" (relating to exchanging expertise and sector-specific matters), or "both administrative and functional". We also asked each stakeholder to rank all interactions mentioned – separately for food and biodiversity links – based on their importance in relation to their organization's goal. The resulting rank data was then standardized on a 10-point scale, with the highest ranked stakeholders given maximally 10 points and the lowest ranked stakeholder assigned minimally a 1-point mark, in equidistant steps. For instance, if a stakeholder listed two connections, the first and second ranked stakeholder would be assigned an importance of 7, and 4, respectively.

Social network analysis

Quantitative social network analysis (SNA) is a powerful tool to draw, compare and identify patterns of interactions within and between stakeholders. SNA can identify stakeholders with prominent power and influence, leading to the design of more effective governance network (Bodin, Crona, and Ernstson 2006). In social network, stakeholders

are represented as nodes whose interactions are represented by links. We used the social network analysis packages "igraph" and "sna" in the R environment to analyze our network data. First, we described the network by investigating individual stakeholders, including their average numbers of collaborations, the abundance of different organizational types, and assessing their involvement in food security and biodiversity conservation. Second, we focused on the links, including link classification (food and/or biodiversity; functional or administrative), and reciprocity. Reciprocity means that both stakeholders A and B reported a link, in contrast to when a link was acknowledged by only A or only B. The extent of reciprocity was tested for significance compared against a null model using a network regression (Robins et al., 2007). Third, we combined food security and biodiversity networks and visualized the interaction between stakeholders (aim 1).

We then evaluated the structural integration of food security and biodiversity governance by quantifying the individual and collaborative integration of and actor (aim 2). We measure a stakeholder's *individual integration* as its proportion of food links relative to its total number of links (i.e. number of food links + number of biodiversity links). A proportion of 0.5 means that an actor is involved in an equal number of many collaborations in food security and biodiversity conservation. A value of 0.5 is interpreted as *high* individual integration of food security and biodiversity. Conversely, *low* individual integration occurs for an actor with a food-link proportion of 0 or 1, which means that this actor has only food links or biodiversity links, respectively.

We measure *collaborative integration* as the percentage of collaborations that involved both topics (rather than one topic only). We statistically tested the "integration hypothesis" that collaborative integration increases as more collaborations are formed. If true, this corresponds to a tendency that stakeholders "thematically complement" existing single-topic collaborations to cover both food security and biodiversity, rather than forging new single-topic collaborations with new partners. We tested this integration hypothesis by calculating Pearson's correlation coefficient *r*, which was tested for significance using a QAP test (Quadratic Assignment Procedure) (Hanneman and Riddle 2005). We defined $\alpha = 0.05$, which means that less than 5% of the 5000 networks generated with QAP simulations had a greater or equal *r* than the observed collaboration network. This procedure tests if the observed percentage of integrative collaborations is the outcome of a real social process rather than occurring by chance. The two measures of governance

integration complement one another conceptually. It is possible that for a stakeholder with an equal number of food and biodiversity links (high individual integration), each of its collaborations is specifically about either food security or biodiversity, rather than about both, which would imply that collaborative integration is in fact low.

We visualized the entire network with both food and biodiversity links, and indicated cohesive subgroups (hereafter called "clusters") within the network. For this, we identified clusters using the walktrap algorithm (Pons and Latapy 2006), which tries to render the clusters with the maximum modularity score. Modularity-based cluster detection defines clusters as having more and stronger links internally among the cluster members, and fewer and weaker links between stakeholders located in different clusters. It assumes a value between 0 and 1 with a higher modularity score indicating clearer network clustering (Newman, 2003; Pons and Latapy, 2006). At a modularity score of 0.470, we identified 12 clusters; this output was checked for consistency using the edge-betweenness algorithm (Newman and Girvan, 2003).

The final part of our analysis identified stakeholders that occupied the most important positions in the network – that is, connecting stakeholders that would otherwise have limited, or no, interactions (aim 3). First, we analyzed stakeholder importance to see if the stakeholders reported as important collaborators in food security were also reported important in biodiversity collaborations – we termed this "stakeholder popularity". To measure the popular stakeholders based on the importance of a stakeholder, we summed the (rank-based) importance of the collaboration provided by the partners.

Second, one form of structural linking occurs when a stakeholder connects other stakeholders who are not directly interconnected, and such linking can be measured by betweenness centrality (Freeman, 1978). Hence, we calculated betweenness centrality to identify the most important connecting stakeholders within each of the 12 clusters. A high betweenness centrality score indicates that the stakeholder plays a crucial connecting role.

Third, we were also interested in identifying the actors that were the most important connecting nodes between different clusters. For this, we performed a Gould-Fernandez brokerage analysis (Gould & Fernandez, 1989). Specifically, we identified stakeholders playing a "liaison role" – that is, stakeholders through which two separate clusters are connected. Similar to the link classification, we classified stakeholders based on their

assigned formal task, into three broad categories. “Administrative stakeholders” were formally mandated with administrative tasks; “Sectoral stakeholders” had agricultural development or conservation as the main task; and “Social stakeholders” had the main formal task of social development aspects. These node level attributes were compared between clusters.

Results

Overall network description

Starting with the network *nodes*, we identified 244 relevant stakeholders. Of the 244 stakeholders, 174 (71%) were simultaneously involved in both food security and biodiversity governance; 56 (23%) had only food security links; 14 (6%) had only biodiversity links. In both food security and biodiversity, government actors accounted for 80% of all actors. Non-governmental organization accounted for 9% (n= 230) and 6 % (n=188) of actors in the food security and biodiversity networks respectively, whereas community groups made up 11% (n= 230) and 14% (n=188) of actors in the food security and biodiversity networks, respectively.

Looking at the network *links*, each actor had on average 20.3 (sd = 14.7) food links and 10.4 (sd = 12.2) biodiversity links. Of 1884 collaborations in total, 944 (50%) were about food security only, 303 (16%) about biodiversity only, and 637 (34%) about both food security and biodiversity. Seventy-two percent of the food security links and 51% of the biodiversity conservation links were reciprocated. We found strong statistical support for reciprocal collaborations between food security and biodiversity actors ($p < 0.001$).

Structural features of the stakeholder networks

Overall, the governance structure of food security and biodiversity conservation was strongly hierarchical, exhibiting many vertical links between the five governance levels, but no horizontal links between woredas (Fig. 4.2a). Despite being on the same governance level, and geographical neighbors, there was no reported horizontal interaction between stakeholders from the three adjacent woredas for either food security or biodiversity. Moreover, there was virtually no reported direct interaction spanning two levels of governance, only ever to the same or the nearest level up or down the governance hierarchy (Fig. 4.2a). For instance, there was no direct vertical interaction between woreda and region

level stakeholders, or between zone and federal level stakeholders; the only exceptions being the non-governmental organization GIZ-SLM and the Ethiopian Wildlife Conservation Authority (Fig. 4.2a).

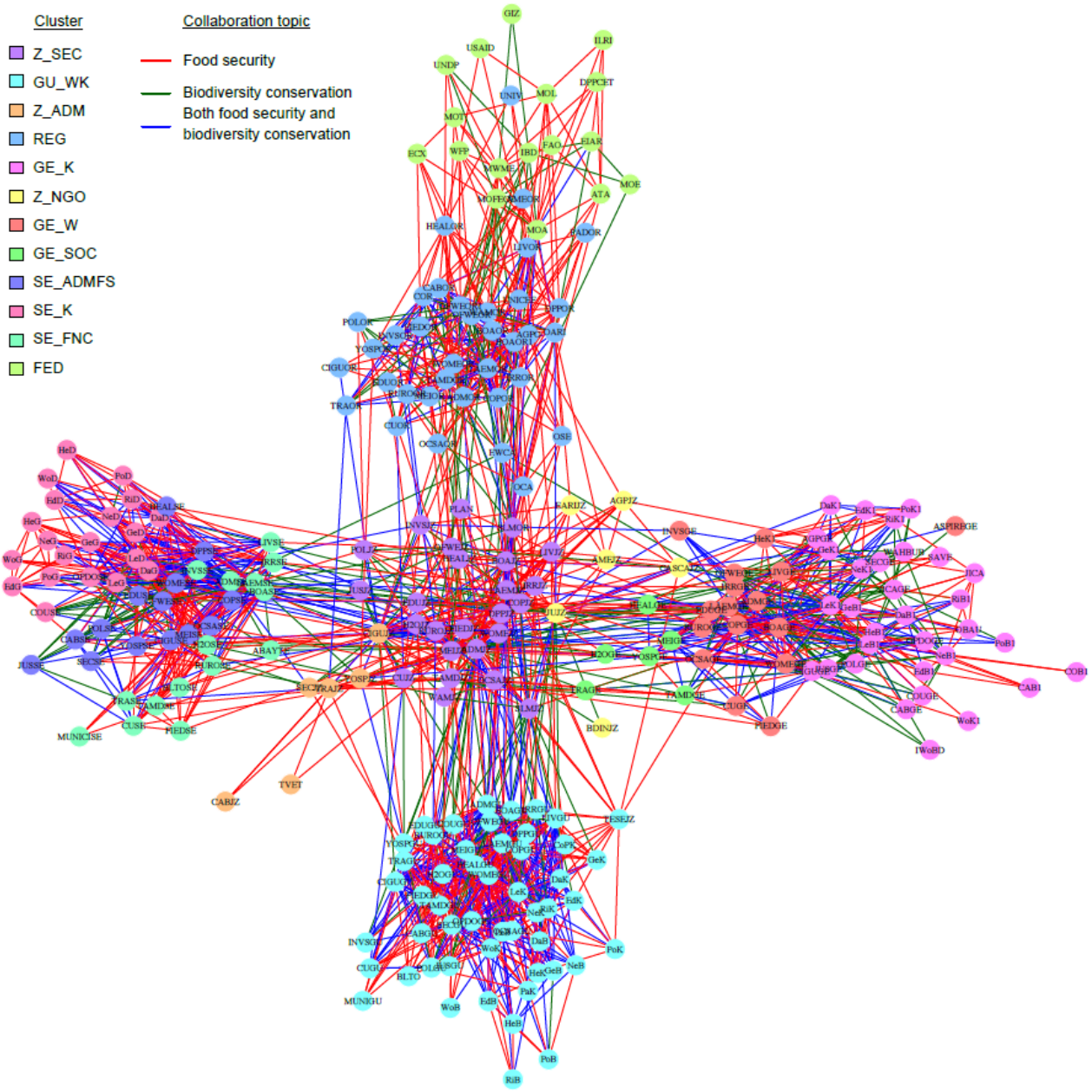


Fig. 4.2 (a)

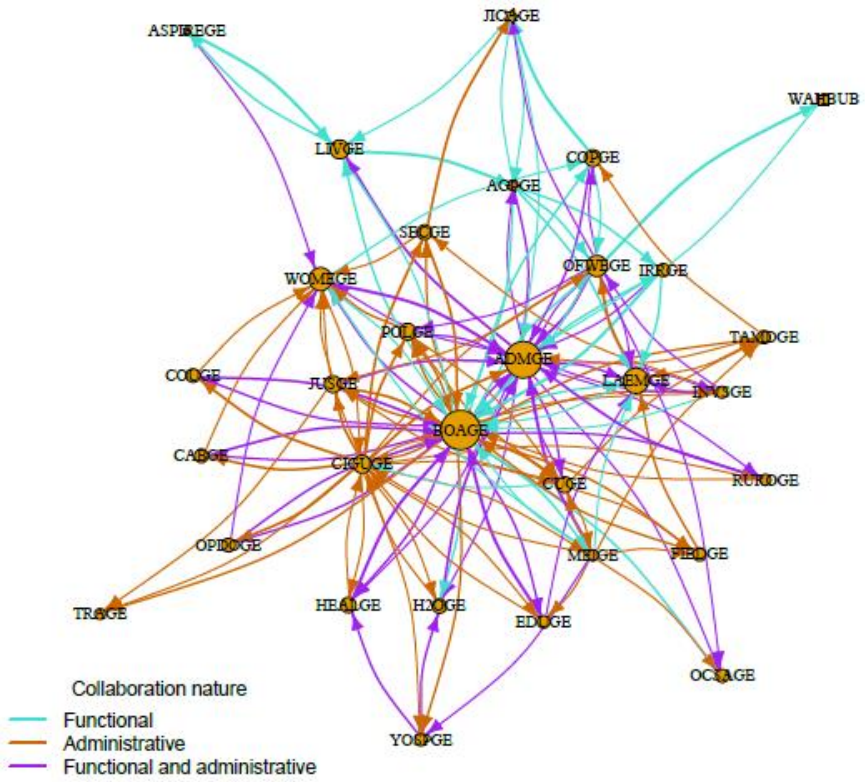


Fig. 4.2(b)

Fig. 4.2. Visualization of the actor network of food security and biodiversity governance. Part (a) shows the overall network and the clusters derived for closely interacting actors. The 12 clusters correspond closely to the tiers of the formal governance system of Ethiopia, indicating a strongly hierarchical structure. The 12 clusters align with the five administration levels: Federal level (FED), regional level (REG), three clusters at the zonal level in the middle (Z_NGO, Z_ADM, Z_SE), Gumay woreda at the bottom (GU_WK), Gera woreda with three clusters on the left (GE_W, GE_K, GE_SOC), and Setema woreda with three clusters on the right (SE_ADMFA, SE_FNC, SE_K). Notably, horizontal links (e.g. between woredas) are largely absent. Part (b) shows the directed biodiversity links for Gera woreda as an example. Line width represents the importance of a given link as judged by collaborating partners. The color of the link indicates the type of link between stakeholders (i.e. administrative, functional, both). Node size is proportional to betweenness centrality, with large nodes denoting stakeholders in connecting positions. For instance, within the Gera woreda, key connecting roles are undertaken by the Bureau of Agriculture (BOAGE) and the Administration Office (ADMGE). For a full list of stakeholder abbreviations, see Supplementary Table S4.1.

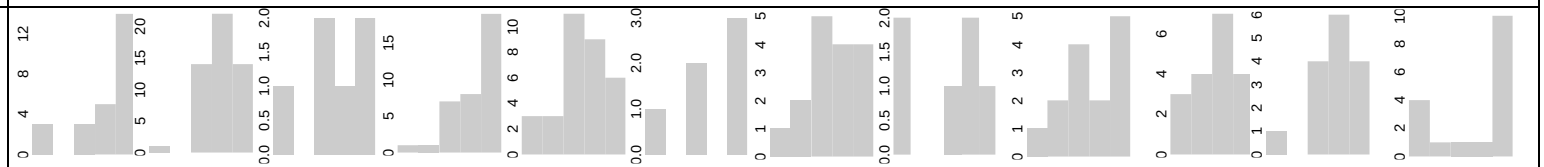
Integration of food security and biodiversity governance

We identified twelve clusters within the network (modularity = 0.47) each consisting of stakeholders with more and stronger links among one another, and fewer and weaker links to stakeholders in other clusters. The clusters approximately matched the formal governance levels and the three woreda subdivisions (Fig. 4.2a).

The clusters differed by *individual integration*, that is, the extent to which actors were involved in equally many collaborations in food security as in biodiversity. Such "well-integrated stakeholders" are represented by the middle bar in the histograms in Table 4.1, whereas "less-integrated stakeholders" with either mostly food security links or mostly biodiversity conservation links are represented by the leftmost and rightmost histogram bars in Table 4.1. Our results indicated that clusters at implementation levels – woreda and kebele (e.g. clusters GU_WK,GE_SOC, and SE_K in Table 4.1) – had a higher proportion of well-integrated stakeholders than clusters at policy levels: zone, region, and federal (clusters Z_SEC, REG and FED; Table 4.1). In clusters with diverse types of stakeholders consisting of governmental, non-governmental and community groups, individual integration was typically higher than in clusters dominated by specific stakeholder types such as only NGOs or only governmental stakeholders.

In addition to the variation in individual integration, *collaborative integration* of food security and biodiversity was higher in clusters consisting of mainly the administrative stakeholders compared to clusters dominated by sectoral stakeholders. Clusters with dominant sectoral stakeholders – be it either in food security or biodiversity – had relatively more collaborations exclusively about either food security or biodiversity (Table 4.1). We also found that clusters with high collaborative integration had a higher proportion of "*both"* administrative and functional link nature (Table 4.1). Five of twelve clusters had at least 30% integrative collaborations at a statistically significant level ($p < 0.05$), whereas the remaining seven clusters had a poor and/or nonsignificant level of collaborative integration ($p > 0.05$)(Table 4.1).

Table 4.1. Characterization of the clusters (Fig. 4.1a shows the location of each cluster in the larger network). Collaborative integration is measured as the percentage of collaborations that integrate food security and biodiversity; an asterisk (*) marks that the integration is statistically significant at $\alpha=0.05$. Individual integration is measured for each actor as the proportion of all collaborations that is about food security, of its total number of collaborations. Thus, 1 means that a stakeholder has only food links, 0 that it has only biodiversity links, and 0.5 that it has equally many food security links and biodiversity links. The histograms show the distribution of indidivual integration in each cluster, with breaks at 0.2, 0.4, 0.6 and 0.8. Thus, high middle bars mean that, in a given cluster, many stakeholders contribute to structural integration of food security and biodiversity, whereas high bars on the right mean that many stakeholders are collaborating on food security only.

Cluster name (see Fig. 4.2A) Short description		**Z_SEC** (Zone, sectoral cluster)	**GU_WK** (Gumay woreda & Kebele)	**Z_ADM** (Zone administration)	**REG** (Region cluster)	**GE_K** (Gera kebele)	**Z_NGO** (Zone NGO dominated)	**GE_W** (Gera woreda)	**GE_SOC** (Gera social sector)	**SE_ADMFS** (Setema administration)	**SE_K** (Setema kebeles)	**SE_FNC** (Setema finance)	**FED** (Federal)
Stakeholders (total)		25	51	6	36	32	6	16	6	14	20	15	17
type %	Govermental	88	82	100	89	53	33	94	100	100	60	93	59
	Community	-	18	-	-	34	-	-	-	-	40	-	-
	Non-governmenttal	12	-	-	11	13	67	6	-	-	-	7	41
Collaborations (total)		195	939	13	431	202	12	115	13	77	172	108	70
nature %	Administrative	19	25	69	13	27	-	11	15	52	6	9	-
	Admin. and funct.	26	48	15	55	45	8	44	23	13	71	56	40
	Functional	54	27	15	31	28	92	44	62	35	23	34	60
Integration of food and biodiversity	Collaborative (%)	18 *	43 *	29	27 *	30 *	11	54 *	50	32	44 *	42 *	3
	Individual												

Stakeholder connecting roles and importance

Stakeholder popularity generally showed strong correspondence between food security and biodiversity. The stakeholders that were considered the most important collaborators, by their partners, in food security were also considered as the most important collaborators in biodiversity (Table 4.2). In particular, administrative stakeholders at the woreda, zonal and regional levels were ranked as the most important stakeholders in both the food security and biodiversity sectors.

Administrative stakeholders also dominated connecting roles between individual stakeholders within clusters as well as between clusters. Administration sector stakeholders such as the administration and security office (SECGU), civil service office (CIGU), kebele leader (LEB1), Women and Childrens Office (WOMENGE) and political ruling party office (OPDOSE) had higher betweenness centrality, indicating their leading role in connecting different stakeholders (see for instance Fig 4.1b for biodiversity conservation in Gera woreda). We found that stakeholders in well-integrated clusters – both for individual integration and collaborative integration – were primarily linked through administrative sector stakeholders (Table 4.2). Weakly integrated clusters, such as regional (REG), federal (*FED)* and zonal *(Z_NGO*) clusters, were connected through sectoral stakeholders such as the disaster prevention and preparedness office (DPPOR), ministry of agriculture (MOA) and Jimma University (JUJZ) (Table 4.2). In a similar pattern, with few exceptions, administrative stakeholders also had the highest liaison brokerage role connecting different clusters (column 4 in Table 4.2).

Table 4.2. Connecting role and popularity of stakeholders in the governance of food security and biodiversity, in the 12 clusters. Stakeholder popularity indicates the importance of a given stakeholder based on the assessment provided by its partners. Rows 1 and 2 show the most popular stakeholders in food security, and biodiversity governance in a given cluster. Rows 3 and 4 indicate the stakeholders with the most prominent connecting roles, as measured by betweenness centrality. Rows 5 and 6 show the stakeholders with the greatest importance for connecting clusters, as indicated by liaison brokerage. Popularity, betweenness-centrality and liaison brokerage scores are rounded to integer and stated within parenthesis. A list of all stakeholder abbreviations is given in Supplementary Table S4.1.

Cluster name (see Fig. 4.2A) Short description		**Z_SEC** (Zone, sectoral cluster**)**	**GU_WK** **(**Gumay woreda & Kebele)	**Z_ADM** (Zone administration)	**REG** (Region cluster)	**GE_K** (Gera kebeles)	**Z_NGO** (Zone NGO dominated)	**GE_W** (Gera woreda)	**GE_SOC** (Gera social sector)	**SE_ADMFS** (Setema administration)	**SE_K** (Setema kebeles)	**SE_FNC** (Setema finance)	**FED** (Federal)
Pop-ularity	Food security	ADMJZ (82)	ADMGU (212)	TRAJZ (12)	ADMOR (144)	LeB1 (81)	AMEJZ (22)	ADMGE (86)	TAMDGE(13)	CIGUSE (35)	LeD (70)	ADMSE (70)	MOA (50)
		BOAJZ (59)	LeK (140)	CABJZ (9)	CABOR (77)	LeK1 (72)	EARIJZ (21)	BOAGE (45)	YOSPGE (12)	MEISE (29)	LeG (62)	BOASE (31)	MOL (49)
		COPJZ (34)	LeB (133)	TVET (6)	COR (71)	JICA (52)	AGPJZ (14)	LIVGE (30)	MEIGE (10)	YOSPSE (23)	OPDOSE (56)	FIEDSE (28)	MWME (56)
	Bio-diversity	ADMJZ (57)	ADMGU (206)	SECJZ (6)	ADMOR (97)	LeB1 (58)	JUJZ (12)	BOAGE (53)	H2OGE (7)	CIGUSE (25)	LeD (69)	ADMSE (56)	IBD (38)
		BOAJZ (59)	LeK (145)	TRAJZ (6)	BOAOR (68)	NeB1 (53)	AGPJZ (0)	ADMGE (45)	HEALGE (7)	WOMESE (20)	LeG (54)	BOASE (39)	MOFEC C (35)
		OFWEJZ (27)	LeB (144)	YOSPJZ(6)	CABOR(55)	DaB1 (44)	AMEJZ (0)	LAEMGE (36)	TAMDGE (5)	CABSE (14)	DaD (50)	LAEMSE (13)	EIAR (29)
Stakeholders Connecting role (Betweenness centrality)		MEIJZ (61)	SECGU (728)	CIGUJZ (6)	DPPOR (146)	LeB1 (173)	JUJZ (4)	WOMEGE (44)	YOSPGE (7)	CIGUSE (41)	OPDOSE (90)	ADMSE (35)	MOA (49)
		BOAJZ (47)	FIEDGU (375)	TRAJZ (4)	WOMEOR (104)	JICAGE (152)	AMEJZ (3)	LAEMGE (25)	TAMDGE (4)	WOMESE (16)	EdG (65)	BOASE (24)	ATA (43)
		TAMDJZ (33)	OCSAGU (240)	-	ADMOR (83)	POLGE (133)	-	BOAGE (15)	-	EDUSE (11)	EdD (2)	LAEMSE (12)	IBD (20)
Clusters Connecting role (Liaison brokerage)		ADMJZ (2954)	ADMGU (24)	CIGUJZ (962)	EWCA (38)	CIGUGE (148)	JUJZ (710)	BOAGE (606)	MEIGE (76)	MEISE (202)	LeD (148)	ADMSE (422)	MOA (4)
		BOAJZ (250)	TESGZ (8)	TRAJZ (58)	OARI (32)	LeK1 (42)	CASCAJZ (28)	ADMGE (290)	HEALGE (58)	DPPCSE (134)	LeG (80)	BOASE (215)	-
		SLMOR (146)	BOAGU (2)	YOSPJZ (54)	OFWEOR (20)	LeB1 (40)	AGPJZ (26)	WOMEGE (112)	YOSPGE (32)	WOMESE (118)	DaG (38)	LAEMSE (39)	-

Discussion

Our study showed that the food security and biodiversity governance structure in southwestern Ethiopia is strongly hierarchical, with limited connectivity both horizontally and spanning between multiple governance levels. The latter creates a structural gap that disconnects policy makers at higher levels from policy implementers at lower levels. On a more positive note, we found that structural integration of food security and biodiversity was facilitated by many individual stakeholders who collaborate on both biodiversity and food security. In this section, we discuss three main findings: (1) the structural gaps between policy making and implementation levels; (2) mechanisms to integrate food security and biodiversity conservation; (3) the roles of individual stakeholders in connecting the network.

Structural gaps limiting harmonization of food security and biodiversity conservation

Many stakeholders (most of which were government authorities) were involved in the governance of both food security and biodiversity. While this large number of stakeholders could cause coordination problems, this risk is likely reduced by the high degree of homogeneity among stakeholders (because most were governmental) and generally high degrees of reciprocity. In such cases, a large number of stakeholder could be advantageous if it promotes collective action and efficient use of resources (Meinzen-Dick, et al., 2002). However, the dominance of government actors could limit the plurality of perspectives, which may hinder effective implementation and limit the social sustainability of policies.

A network perspective of governance suggests that sustainability is enhanced when there are multiple horizontal and vertical connections among stakeholders, that is, when a governance network spans both multiple actors and levels (Candel, 2014; Alexander et al 2017). One key structural gap we identified is that there were very few horizontal linkages, for example between the three geographically adjacent and ecologically connected woredas. Absence of such horizontal interactions essentially hampers the integration of interdependent goals, and could lead to ecological fragmentation, impede collective action, block flows of knowledge, resources and experiences, and hence could create social-ecological misfits. What we observed is the opposite of what existing studies on social-ecological systems have routinely recommended – namely that cross-boundary governance of natural resources is critical for coordination, collective action, and minimizing possible

conflicts and tradeoffs (Bergsten et al., 2014; Berkes and Seixas, 2008). Similar to horizontal cross-boundary interaction, effective governance of food security and biodiversity requires a multilevel governance network that coordinates stakeholders across administrative and political levels, involving policy making and implementing stakeholders. Such vertical interaction is necessary to facilitate the sharing of resources and experience, which could help local actors manage challenges of integration (Alexander et al., 2017). Vertical interaction, however, was missing in southwestern Ethiopia, with stakeholders only interacting with others at the same level or the level immediately above or below. Therefore, there is a need for better multisectoral and multiscalar coordination and interaction between stakeholders for the integration of food security and biodiversity conservation, tradeoff management, and the identification and exploitation of potential synergies between food security and biodiversity conservation. Notably, not all social-ecological problems require vertical and horizontal governance networks, nor is there a generic, fixed governance network that fits any given dynamic social-ecological system (Ostrom, 2009; Alexander et al, 2017). However, with the strong interdependence of food security and biodiversity, and the multiplicity of interests around food security and biodiversity, a governance network that harnesses both horizontal and vertical interaction of heterogeneous stakeholders seems essential (Cumming et al., 2006; Ostrom, 2009; Alexander et al, 2017).

The observed network structure could also produce an implementation deficit because of discrepancies between policy goals and on-ground implementation (Leventon and Antypas, 2012). In food security and biodiversity conservation, the translation of good policy and plans into practice through proper implementation is crucial as the lack thereof leads to poor integration (Esa, 2011; Hailemariam et al., 2016). Therefore, there is a need for multisectoral and multiscalar coordination and interaction between stakeholders for the integration of food security and biodiversity conservation, tradeoff management, and the identification and exploitation of potential synergies between food security and biodiversity conservation.

Not all social-ecological problems require stakeholders vertical and horizontal governance networks, nor there is a fixed governance network that fits with the dynamic social-ecological system (Ostrom, 2009; Alexander et al, 2017). However, with the strong interdependence of food security and biodiversity, and multiplicity of stakeholders interest

around the food security and biodiversity, appropriate governance network that harness both horizontal and vertical interaction of heterogeneous stakeholders across different geographical and governance levels is essential (Cumming et al., 2006; Ostrom, 2009; Alexander et al, 2017).

Integration mechanisms

Our study found a surprisingly high level of integration of food security and biodiversity – nearly 70% of stakeholders were involved in both food security and biodiversity conservation collaborations. The integration of food security and biodiversity at a stakeholder level takes two forms: individual integration and collaborative integration (see Introduction and Methods for details). While the level of individual integration is mainly an outcome of the routines, policies and activities of an individual stakeholder, collaborative integration always involves two stakeholders, with different roles, beliefs, experiences, and capacities. Collaborative integration is a requirement for inter-organizational negotiation, learning, and conflict resolution to integrate food security and biodiversity. The way collaborative stakeholders perceive the importance of dual goals may affect the outcomes of policy. Some stakeholders weight two goals equally, while other stakeholders may see one goal as purely secondary that either helps or hinders their main goal. In our case, a stakeholder may perceive biodiversity conservation from a purely utilitarian perspective because it can support – or in some cases prevent – food security (Hailemariam et al., 2016). From such a stakeholder's perspective, *individual* integration could facilitate the harmonization of food security and biodiversity goals. However, a lack of *collaborative* integration could still pose challenges for the system-wide integration of food security and biodiversity goals, because coordination among stakeholders would be weak. Moreover, *individual* integration could also cause problems in collaborative integration by creating redundancy, lacunae and incoherence. In such instances, different stakeholders perform similar tasks, while important tasks are neglected, or stakeholders pursue contradictory interests and priorities despite being motivated by the same general goal (Peter, 1998).

Unlike individual integration, collaborative integration triggers important social mechanisms of coordination that prevent single-goal agendas, and competition and fragmentation among stakeholders. Despite ample evidence on the importance of cross-sectoral integration for the harmonization of food security and biodiversity goals

(Björklund et al., 2012; Torquebiau 2012), we specifically recommend that future studies keep in mind that individual integration is not enough – but that harmonization at the system level requires collaborative integration.

Most of the individual and collaborative integration of food security and biodiversity was found at the implementation (kebele and woreda) level. Integration was much poorer at the policy level (zone, region and national), where actors tended to work on either food security or biodiversity conservation. Although the high level of structural integration at the implementation level looks promising at first glance, we note that its success depends on how integration takes place in practice. Two practical challenges require further investigation. First, the success of policy could be limited or prevented because of a misalignment between the policies and local needs (Leventon and Laudan, 2017). Policies rarely addresses local needs, which can cause an implementation deficit. Second, integration at the implementation level could be limited by a lack of authority and the resources made available to local actors (Leventon and Antypas, 2012; USAID, 2008). The success of a policy depends on the capacity and will of implementation level stakeholders (Jones et al., 2016). The capacities of local level actors in many instances may need to be enhanced.

The connecting roles of different stakeholders

In the governance of a complex social-ecological system, a stakeholder's structural position and the ability to exercise power are crucial. In Ethiopia, we have shown that stakeholders with formal administrative power most often had liaison roles and high popularity, both within and between governance clusters. In particular, clusters with well-integrated stakeholders – both individually and collaboratively – were typically connected through administrative government organizations. The source of power held by these stakeholders could emerge from the central structural position they held in the governance network, but it could also stem from their formal authority or from their popularity within the network (Adger et al, 2005). On the one hand, these powerful connecting stakeholders could enhance the governance network – facilitating integration of food security and biodiversity – through resource mobilization, fostering collective action, and enabling flows of knowledge, resources and information (Adger et al, 2005; Hahn et al., 2006). Notwithstanding these opportunities, however, there is a risk that the dominance of powerful (governmental) administrative stakeholders could be to the detriment of the

effectiveness of the governance network as a whole. For example, power abuse, withholding of essential information, centralization of decision-making, and coercive imposition of own interests could be counterproductive. For the case study area, the dominance of governmental actors, complemented by the hierarchical governance structure, could easily lead to power capture, where the interests of few powerful stakeholders could override those of many other stakeholders. Consequently, this may erode trust between stakeholders, and hence affect the integration of food security and biodiversity goals (Adger et al, 2005; Bixler et al, 2016). In addition to power relations, other factors such the capacity, willingness, and the transaction costs associated with mobilizing and connecting stakeholders can affect the effectiveness of a given governance network (Adger et al, 2005).

Conclusion

The harmonization of food security and biodiversity conservation governance requires an appropriate governance arrangement. By adopting a governance network perspective, our study underlined that integration of food security and biodiversity conservation requires more strongly interconnected stakeholders both horizontally and vertically. We identified structural gaps that have relevance to social-ecological systems beyond food security and biodiversity. First, governance networks that foster stakeholders' multi-level ties across jurisdictions, and enhance multi-sector interaction would likely improve integration outcomes, social learning, provide opportunities to identify integration problems and hence improve institutional fit. Especially for stakeholders in adjacent jurisdictions that are not currently interacting, efficiency in the governance network could be improved through simple interaction such as sharing of experience, information, and communication. While we urge for more interactions (even quite simple ones), we also recognize that more interconnections per se are not a panacea, because overly large networks with high stakeholder diversity can lead to high transaction costs and therefore may be inefficient.

Second, individual integration may help individual stakeholders to pursue their own respective goals in a coherent fashion, but collaborative integration will facilitate system-level integration of food security and biodiversity conservation. Third, stakeholders with connecting roles within and between clusters will be most successful when there is complementarity between their formal authority, structural position, interest, motivations and power. However, unless properly managed, the concentration of multiple sources of

power on particular stakeholders could also lead to manipulation and conflict in the governance network. Notwithstanding the importance of understanding network-related impediments to the integration of food security and biodiversity conservation, we urge that future work also examine how the process and functioning of governance networks affect the integration of food security and biodiversity. For example, even in a suitable network structure, process-related governance challenges may arise from institutional mismatches, policy incoherence and institutional interplay.

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Supplementary material

Table S4.1: A list of all stakeholders and their abbreviations. The first column gives the stakeholder's acronym as it is used in the main paper, while the full name of the actors is given in the second column. The third and fourth columns indicate stakeholders' administrative levels and the name of the corresponding level respectively. The fifth column shows the type of organization as CG (Community Groups); GO (governmental organizations); and NGO (Non-governmental organizations). The last column indicates the 12 cluster names as used in the main paper to which the stakeholders belong (see Fig. 4.2). Accordingly, GU_WK: indicates cluster consisting stakeholders in Gumay woreda and its kebeles. SE_K: Cluster dominated by kebele level stakeholders in Setema woreda. SE_ADMFS: cluster formed at Setema woreda dominantly consisting stakeholders in administration and finance sections. SE_FNC: cluster formed at Setema woreda dominantly consisting stakeholders in finance sections. GE_W: Cluster consisting of stakeholders working in food security and biodiversity in Gera woreda. GE_K: Cluster dominated by kebele level stakeholders in Gera woreda. GE_SOC: cluster formed at Gera woreda dominantly consisting stakeholders in social sections. Z_ADM: cluster formed at Jima zone dominantly consisting stakeholders in administration. Z_NGO: cluster formed at Jima zone dominantly consisting non-governmental organizations. Z_SEC: cluster formed at Jima zone dominantly consisting stakeholders working in development sectors including food security and biodiversity. REG: cluster consisting all stakeholders in food security and biodiversity working at regional level. FED: cluster consisting stakeholders in food security and biodiversity working at federal level.

Stakeholder acronym	Full name of stakeholders	Administration Level	Administration name	Type of organization	Cluster name
PoK	Poor community group	Kebele	Kuda kufi	CG	GU_WK
RiK	Rich community goup	Kebele	Kuda kufi	CG	GU_WK
GeK	General community	Kebele	Kuda kufi	CG	GU_WK
NeK	Community network leaders	Kebele	Kuda kufi	CG	GU_WK
LeK	Kebele leaders	Kebele	Kuda kufi	GO	GU_WK
EdK	Education office	Kebele	Kuda kufi	GO	GU_WK

HeK	Health extension office	Kebele	Kuda kufi	GO	GU_WK
DaK	Agricultural and natural resources development agents	Kebele	Kuda kufi	GO	GU_WK
PaK	Ruling political party (OPDO) office	Kebele	Kuda kufi	GO	GU_WK
CoPK	Jawi multipurpose cooperative	Kebele	Kuda kufi	CG	GU_WK
WoK	Women and children's affairs representative office	Kebele	Kuda kufi	GO	GU_WK
PoB	Poor community group	Kebele	Bereha Werango	CG	GU_WK
RiB	Rich community group	Kebele	Bereha Werango	CG	GU_WK
GeB	General community	Kebele	Bereha Werango	CG	GU_WK
NeB	Community network leaders	Kebele	Bereha Werango	CG	GU_WK
LeB	Kebele leaders office	Kebele	Bereha Werango	GO	GU_WK
EdB	Education office	Kebele	Bereha Werango	GO	GU_WK
HeB	Health extension office	Kebele	Bereha Werango	GO	GU_WK
DaB	Agricultural and natural resources development agents office	Kebele	Bereha Werango	GO	GU_WK
WoB	Women and children's affairs representative office	Kebele	Bereha Werango	GO	GU_WK
PoD	Poor community group	Kebele	Difo Mani	CG	SE_K
RiD	Rich community group	Kebele	Difo Mani	CG	SE_K
GeD	General community	Kebele	Difo Mani	CG	SE_K

NeD	Community network leaders	Kebele	Difo Mani	CG	SE_K
LeD	Kebele leaders office	Kebele	Difo Mani	GO	SE_K
EdD	Education office	Kebele	Difo Mani	GO	SE_K
HeD	Health extension office	Kebele	Difo Mani	GO	SE_K
DaD	Agricultural and natural resources development agents office	Kebele	Difo Mani	GO	SE_K
WoD	Women and children's affairs representative office	Kebele	Difo Mani	GO	SE_K
PoG	Poor community group	Kebele	Gido Beri	CG	SE_K
RiG	Rich community group	Kebele	Gido Beri	CG	SE_K
GeG	General community	Kebele	Gido Beri	CG	SE_K
NeG	Community network leaders	Kebele	Gido Beri	CG	SE_K
LeG	Kebele leaders office	Kebele	Gido Beri	GO	SE_K
EdG	Education office	Kebele	Gido Beri	GO	SE_K
HeG	Health extension office	Kebele	Gido Beri	GO	SE_K
DaG	Agricultural and natural resources development agents office	Kebele	Gido Beri	GO	SE_K
WoG	Women and children's affairs representative office	Kebele	Gido Beri	GO	SE_K
PoK1	Poor community group	Kebele	Kella Hareri	CG	GE_K
RiK1	Rich community group	Kebele	Kella Hareri	CG	GE_K
GeK1	General community	Kebele	Kella Hareri	CG	GE_K
NeK1	Community network leaders	Kebele	Kella Hareri	CG	GE_K

LeK1	Kebele leaders office	Kebele	Kella Hareri	GO	GE_K
EdK1	Education office	Kebele	Kella Hareri	GO	GE_K
HeK1	Health extension office	Kebele	Kella Hareri	GO	GE_W
DaK1	Agricultural and natural resources development agents office	Kebele	Kella Hareri	GO	GE_K
WoK1	Women and children's affairs representative office	Kebele	Kella Hareri	GO	GE_K
PoB1	Poor community group	Kebele	Borcho Deka	CG	GE_K
RiB1	Rich community group	Kebele	Borcho Deka	CG	GE_K
GeB1	General community	Kebele	Borcho Deka	CG	GE_K
NeB1	Community network leaders	Kebele	Borcho Deka	CG	GE_K
LeB1	Kebele leaders office	Kebele	Borcho Deka	GO	GE_K
EdB1	Education office	Kebele	Borcho Deka	GO	GE_K
HeB1	Health extension office	Kebele	Borcho Deka	GO	GE_K
DaB1	Agricultural and natural resources development agents office	Kebele	Borcho Deka	GO	GE_K
IwoBD	Women and children's affairs office	Kebele	Borcho Deka	CG	GE_K
OBAU	Oba multipurpose cooperative office	Kebele	Borcho Deka	CG	GE_K
CAB1	Executive cabinet office	Kebele	Borcho Deka	GO	GE_K
COB1	Executive council office	Kebele	Borcho Deka	GO	GE_K
BOAGU	Bureau of agriculture and natural resource	woreda	Gumay	GO	GU_WK

	management office				
IRRGU	Irrigation development authority office	woreda	Gumay	GO	GU_WK
DPPGU	Disaster prevention and preparedness commission office	woreda	Gumay	GO	GU_WK
LIVGU	Livestock and fish resource development office	woreda	Gumay	GO	GU_WK
COPGU	Cooperative promotion agency office	woreda	Gumay	GO	GU_WK
LAEMGU	Land administration and environmental protection office	woreda	Gumay	GO	GU_WK
MEIGU	Micro and small enterprise development agency office	woreda	Gumay	GO	GU_WK
OCSAGU	Oromia credit and finance share company office	woreda	Gumay	GO	GU_WK
TAMDGU	Trade and market development office	woreda	Gumay	GO	GU_WK
FIEDGU	Finance and economic development office	woreda	Gumay	GO	GU_WK
EDUGU	Education office	woreda	Gumay	GO	GU_WK
HEALGU	Health office	woreda	Gumay	GO	GU_WK
H2OGU	Water, mineral and energy office	woreda	Gumay	GO	GU_WK
WOMEGU	Women and children's affairs office	woreda	Gumay	GO	GU_WK

CIGUGU	Civil service and good governance office	woreda	Gumay	GO	GU_WK
YOSPGU	Youth and sport office	woreda	Gumay	GO	GU_WK
ADMGU	Administration office	woreda	Gumay	GO	GU_WK
OFWEGU	Oromia forest and wildlife enterprise	woreda	Gumay	GO	GU_WK
INVSGU	Investment commission	woreda	Gumay	GO	GU_WK
ROGU	Rural road authority	woreda	Gumay	GO	GU_WK
TRAGU	Transport authority	woreda	Gumay	GO	GU_WK
CUGU	Revenues and customs authority	woreda	Gumay	GO	GU_WK
POLGU	Police commission	woreda	Gumay	GO	GU_WK
JUSGU	Justice office	woreda	Gumay	GO	GU_WK
CABGU	Executive cabinet office	woreda	Gumay	GO	GU_WK
COUGU	Executive council office	woreda	Gumay	GO	GU_WK
OPDOGU	Ruling political party(OPDO) office	woreda	Gumay	GO	GU_WK
BLTO	Education and vocational training office	woreda	Gumay	GO	GU_WK
MUNIGU	Municipality office	woreda	Gumay	GO	GU_WK
SECGU	Security and administration office	woreda	Gumay	GO	GU_WK
BOAGE	Bureau of agriculture and natural resource management office	woreda	Gera	GO	GE_W

IRRGE	Irrigation development authority	woreda	Gera	GO	GE_W
LIVGE	Livestock and fish resource development office	woreda	Gera	GO	GE_W
COPGE	Cooperative promotion agency	woreda	Gera	GO	GE_W
LAEMGE	Land administration and environmental protection office	woreda	Gera	GO	GE_W
MEIGE	Micro and small enterprise development agency	woreda	Gera	GO	GE_SOC
OCSAGE	Oromia credit and finance share company	woreda	Gera	GO	GE_W
TAMDGE	Trade and market development office	woreda	Gera	GO	GE_SOC
FIEDGE	Finance and economic development office	woreda	Gera	GO	GE_W
EDUGE	Education office	woreda	Gera	GO	GE_W
HEALGE	Health office	woreda	Gera	GO	GE_SOC
H2OGE	Water, mineral and energy office	woreda	Gera	GO	GE_SOC
SAVE	Save the children international	woreda	Gera	NGO	GE_K
JICAGE	Japan international cooperation agency (JICA)	woreda	Gera	NGO	GE_K
WAHBUB	Community forest users group	woreda	Gera	CG	GE_K
JICA	Japan international	woreda	Gera	NGO	GE_K

	cooperation agency (JICA)				
WOMEGE	Women and children's affairs office	woreda	Gera	GO	GE_W
CIGUGE	Civil service and good governance office	woreda	Gera	GO	GE_K
YOSPGE	Youth and sport office	woreda	Gera	GO	GE_SOC
ADMGE	Administration office	woreda	Gera	GO	GE_W
OFWEGE	Oromia forest and wildlife enterprise	woreda	Gera	GO	GE_W
INVSGE	Investment commission	woreda	Gera	GO	GE_W
RUROGE	Rural road authority	woreda	Gera	GO	GE_W
TRAGE	Transport authority	woreda	Gera	GO	GE_SOC
CUGE	Revenues and customs authority	woreda	Gera	GO	GE_W
POLGE	Police commission	woreda	Gera	GO	GE_K
JUSGE	Justice office	woreda	Gera	GO	GE_K
CABGE	Executive cabinet office	woreda	Gera	GO	GE_K
COUGE	Executive council office	woreda	Gera	GO	GE_K
OPDOGE	Ruling political party office	woreda	Gera	GO	GE_K
ASPIREGE	ASPIRE	woreda	Gera	NGO	GE_W
AGPGE	Agricultural growth program	woreda	Gera	NGO	GE_K
SECGE	Security and administration office	woreda	Gera	GO	GE_K
BOASE	Bureau of agriculture and natural resource management office	woreda	Setema	GO	SE_FNC

IRRSE	Irrigation development authority	woreda	Setema	GO	SE_FNC
DPPSE	Disaster prevention and preparedness commission	woreda	Setema	GO	SE_ADMFS
LIVSE	Livestock and fish resource development office	woreda	Setema	GO	SE_FNC
COPSE	Cooperative promotion agency	woreda	Setema	GO	SE_ADMFS
LAEMSE	Land administration and environmental protection office	woreda	Setema	GO	SE_FNC
MEISE	Micro and small enterprise development agency	woreda	Setema	GO	SE_ADMFS
OCSASE	Oromia credit and finance share company	woreda	Setema	GO	SE_ADMFS
TAMDSE	Trade and market development office	woreda	Setema	GO	SE_FNC
FIEDSE	Finance and economic development office	woreda	Setema	GO	SE_FNC
EDUSE	Education office	woreda	Setema	GO	SE_ADMFS
HEALSE	Health office	woreda	Setema	GO	SE_ADMFS
H2OSE	Water, mineral and energy office	woreda	Setema	GO	SE_FNC
WOMESE	Women and children's affairs office	woreda	Setema	GO	SE_ADMFS
CIGUSE	Civil service and good governance office	woreda	Setema	GO	SE_ADMFS

YOSPSE	Youth and sport office	woreda	Setema	GO	SE_ADMFS
ADMSE	Administration office	woreda	Setema	GO	SE_FNC
INVSSE	Investment commission	woreda	Setema	GO	SE_FNC
RUROSE	Rural road authority	woreda	Setema	GO	SE_FNC
TRASE	Transport authority	woreda	Setema	GO	SE_FNC
ABAYTE	Abay tefases project office	woreda	Setema	NGO	SE_FNC
OFWESE	Oromia forest and wildlife enterprise	woreda	Setema	GO	SE_ADMFS
CUSE	Revenues and customs authority	woreda	Setema	GO	SE_FNC
POLSE	Police commission	woreda	Setema	GO	SE_ADMFS
JUSSE	Justice office	woreda	Setema	GO	SE_ADMFS
CABSE	Executive cabinet office	woreda	Setema	GO	SE_ADMFS
COUSE	Executive council office	woreda	Setema	GO	SE_K
OPDOSE	Ruling political party (OPDO)	woreda	Setema	GO	SE_K
BLTOSE	Education and vocational training office	woreda	Setema	GO	SE_FNC
MUNICISE	Municipality office	woreda	Setema	GO	SE_FNC
SECSE	Security and administration office	woreda	Setema	GO	SE_ADMFS
BOAJZ	Bureau of agriculture and natural resource management office	Zone	Jima	GO	Z_SEC
IRRJZ	Irrigation development authority	Zone	Jima	GO	Z_SEC

DPPJZ	Disaster prevention and preparedness commission	Zone	Jima	GO	Z_SEC
LIVJZ	Livestock and fish resource development office	Zone	Jima	GO	Z_SEC
COPJZ	Cooperative promotion agency	Zone	Jima	GO	Z_SEC
LAEMJZ	Land administration and environmental protection office	Zone	Jima	GO	Z_SEC
MEIJZ	Micro and small enterprise development agency	Zone	Jima	GO	Z_SEC
OCSAJZ	Oromia credit and finance share company	Zone	Jima	GO	Z_SEC
TAMDJZ	Trade and market development office	Zone	Jima	GO	Z_SEC
FIEDJZ	Finance and economic development office	Zone	Jima	GO	Z_SEC
EDUJZ	Education office	Zone	Jima	GO	Z_SEC
HEALJZ	Health office	Zone	Jima	GO	Z_SEC
H2OJZ	Water, mineral and energy office	Zone	Jima	GO	Z_SEC
WOMEJZ	Women and children's affairs office	Zone	Jima	GO	Z_SEC
CIGUJZ	Civil service and good governance office	Zone	Jima	GO	Z_ADM
YOSPJZ	Youth and sport office	Zone	Jima	GO	Z_ADM
ADMJZ	Administration office	Zone	Jima	GO	Z_SEC

INVSJZ	Investment commission	Zone	Jima	GO	Z_SEC
ROJZ	Rural road authority	Zone	Jima	GO	Z_SEC
TRAJZ	Transport authority	Zone	Jima	GO	Z_ADM
CUJZ	Revenues and customs authority	Zone	Jima	GO	Z_SEC
POLJZ	Police commission	Zone	Jima	GO	Z_SEC
CABJZ	Executive cabinet office	Zone	Jima	GO	Z_ADM
SECJZ	Security and administration office	Zone	Jima	GO	Z_ADM
TESEJZ	Techno serve	Zone	Jima	GO	GU_WK
SLMJZ	Sustainable land management/GIZ project	Zone	Jima	NGO	Z_SEC
JUJZ	Jima university	Zone	Jima	NGO	Z_NGO
CASCAJZ	Capacity building for scaling up best practices project	Zone	Jima	NGO	Z_NGO
EARIJZ	Ethiopian agricultural research institute	Zone	Jima	GO	Z_NGO
OFWEJZ	Oromia forest and wildlife enterprise	Zone	Jima	GO	Z_SEC
JUSJZ	Justice office	Zone	Jima	GO	Z_SEC
WAMJZ	Water, mineral and energy office	Zone	Jima	GO	Z_NGO
BDINJZ	Institute of biodiversity conservation	Zone	Jima	GO	Z_SEC
AGPJZ	Agricultural growth program office	Zone	Jima	NGO	Z_NGO
AMEJZ	Agricultural mechanization research center	Zone	Jima	NGO	Z_NGO

PLAN	Plan international	Zone	Jima	NGO	Z_SEC
TVET	Training and vocational education office	Zone	Jima	GO	Z_ADM
BOAOR	Bureau of agriculture and natural resource management, extension division	Region	Oromia	GO	REG
BOAOR1	Bureau of agriculture and natural resource management, natural resource division	Region	Oromia	GO	REG
IRROR	Irrigation development authority	Region	Oromia	GO	REG
DPPOR	Disaster prevention and preparedness commission	Region	Oromia	GO	REG
LIVOR	Livestock and fish resource development bureau	Region	Oromia	GO	REG
COPOR	Cooperative promotion agency	Region	Oromia	GO	REG
LAEMOR	Land administration and environmental protection bureau	Region	Oromia	GO	REG
MEIOR	Micro and small enterprise development agency	Region	Oromia	GO	REG
OCSAOR	Oromia credit and finance share company	Region	Oromia	GO	REG
TAMDOR	Trade and market development bureau	Region	Oromia	GO	REG

FIEDOR	Finance and economic development bureau	Region	Oromia	GO	REG
EDUOR	Education bureau	Region	Oromia	GO	REG
HEALOR	Health bureau	Region	Oromia	GO	REG
WOMEOR	Women and children's affairs bureau	Region	Oromia	GO	REG
CIGUOR	Civil service and good governance bureau	Region	Oromia	GO	REG
YOSPOR	Youth and sport bureau	Region	Oromia	GO	REG
ADMOR	Administration bureau	Region	Oromia	GO	REG
OFWEOR1	Oromia forest and wildlife enterprise, forest	Region	Oromia	GO	REG
OFWEOR	Oromia forest and wildlife enterprise, wildlife	Region	Oromia	GO	REG
INVSOR	Investment commission	Region	Oromia	GO	REG
RUROOR	Rural road authority	Region	Oromia	GO	REG
TRAOR	Transport authority	Region	Oromia	GO	REG
CUOR	Revenues and customs authority	Region	Oromia	GO	REG
POLOR	Police commission	Region	Oromia	GO	REG
COR	Executive council bureau	Region	Oromia	GO	REG
CABOR	Executive cabinet bureau	Region	Oromia	GO	REG
WAMOR	Water, mineral and energy bureau	Region	Oromia	GO	REG
AGPO	Agricultural growth program	Region	Oromia	NGO	REG

SLMOR	Sustainable land management/GIZ project	Region	Oromia	NGO	REG
OCA	Cooperative promotion agency	Region	Oromia	NGO	REG
OARI	Oromia agricultural research institute	Region	Oromia	GO	REG
AMEOR	Agricultural mechanization research center	Region	Oromia	GO	REG
OSE	Oromia seed enterprise bureau	Region	Oromia	NGO	REG
UNIV	University	Region	Oromia	GO	REG
PADOR	Pastoral development bureau	Region	Oromia	GO	REG
ATA	Agricultural transformation agency	Federal	Ethiopia	NGO	FED
MOA	Ministry of agriculture	Federal	Ethiopia	GO	FED
MOL	Ministry of livestock	Federal	Ethiopia	GO	FED
DPPCET	Disaster prevention and preparedness commission	Federal	Ethiopia	GO	FED
ILRI	International livestock institute	Federal	Ethiopia	NGO	FED
FAO	Food and agricultural organization	Federal	Ethiopia	NGO	FED
MWME	Ministry of water, mines and energy	Federal	Ethiopia	GO	FED
MOT	Ministry of trade	Federal	Ethiopia	GO	FED
ECX	Ethiopian commodity exchange	Federal	Ethiopia	GO	FED

UNDP	United Nation Development Program	Federal	Ethiopia	NGO	FED
UNICEF	United Nation International Children Emergency Fund	Federal	Ethiopia	NGO	REG
USAID	United States Of America International Development	Federal	Ethiopia	NGO	FED
WFP	World Food Program	Federal	Ethiopia	NGO	FED
EIAR	Ethiopian institute agricultural research	Federal	Ethiopia	GO	FED
IBD	Institute of biodiversity	Federal	Ethiopia	GO	FED
MOFECC	Ministry of forest, environment and climate change	Federal	Ethiopia	GO	FED
EWCA	Ethiopian wildlife conservation authority	Federal	Ethiopia	GO	FED
MOE	Ministry of education	Federal	Ethiopia	GO	FED
GIZ	Deutsche Gesellschaft Für Internationale	Federal	Ethiopia	NGO	FED

Chapter V

Chapter V

Governance challenges at the interface of food security and biodiversity: a multi-level case study from Ethiopia

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In preparation for submission

View of one of the study woredas, Setema woreda, Gatira town

Abstract

Sustainable development requires improving outcomes related to both food security and biodiversity conservation. Achieving this integration requires a good fit between institutional and social-ecological systems, which is challenging because of the multiplicity of actors and policy sectors involved. Identification of these challenges is therefore important to devise sustainable solutions. Taking a multi-level governance perspective, this study aimed to identify governance challenges related to food security, biodiversity, and their integrated governance. We conducted a qualitative case study in southwestern Ethiopia, where we interviewed 201 stakeholder organizations from local to national levels. We found three key categories of governance challenges that merit critical attention: (1) Institutional misfits including institutional overlaps, gaps and instability resulting in redundancy and lacunae. (2) Problems of institutional interplay arising from horizontal and vertical institutional interactions involving limited coordination, and fragmentation. (3) Policy incoherence such as contradictions among policy goals and instruments. These governance challenges affected the individual sectors of food security and biodiversity conservation, and also posed challenges for the integrated governance of food security and biodiversity, often in a more pronounced way. Based on our findings, we argue that governance interventions for enhanced sustainability in southwestern Ethiopia require a more holistic and collaborative approach that ensures institutional fit, pays attention to institutional interplay, and ensures consistency across policy goals.

Keywords**:** Biodiversity, Food security, Governance, Institutional fit, Institutional interplay, Policy coherence

Introduction

Ensuring food security and biodiversity conservation simultaneously poses a pivotal challenge for contemporary sustainability governance (Chappell and LaValle, 2011). Food security involves the sufficient production and supply of nutritious and culturally preferred food, the physical and economic access to food, and its proper utilization by the population for a healthy and productive life (FAO, 2014); whereas biodiversity refers to the variability among all living organisms, including diversity within and between species and their habitats (Convention on Biological Diversity, 1992). Although widely treated as competing policy goals, integrating food security and biodiversity conservation has become an increasingly recognized goal of sustainability governance (Brussaard et al., 2010). However, the integrated governance of food security and biodiversity is not only a biophysical challenge but also a political and institutional one, given the multitude of institutions and policies involved, as well as their complex interactions across multiple levels of governance.

Strong arguments in the fields of international development and nature conservation have been made that food security will not be achieved without negatively affecting biodiversity and vice versa (Tscharntke et al., 2012). But a growing body of literature challenges this position and proposes that food security and biodiversity conservation can and should be achieved simultaneously (Fischer et al., 2018; Tscharntke et al., 2012). Their successful integration, however, requires a close fit between governance systems and the characteristics of particular social-ecological systems (Guerrero et al., 2015). Strategies are required to govern the food security and biodiversity sectors individually, as well as to address their complex interactions (Eriksen et al., 2009; Brussard et al., 2010).

In this paper, we investigate such possible strategies by examining the governance challenges associated within the food security and biodiversity sectors, and their integrated governance, in a social-ecological case study system. We conceptualize governance as comprising the *structures* (type and nature of institutions, and institutional arrangement), *processes* (of policy, plans, rules and their enforcement) and *policy content* influencing food security and biodiversity conservation outcomes (Hill, 2013; Mertens et al., 2015).Thus, in the context of this study, governance is understood through the lens of institutions that develop policies, rules and plans; as well as the organizations established to implement these rules. Such institutions are multilevel, operating across several interdependent tiers (e.g. national, regional, district, local); and they include a broad range of stakeholders who interplay over multiple jurisdictions

(Hooghe and Marks, 2001). They are also multi-sectoral, including the policy sectors of food and biodiversity as well as other, potentially broader sectors that influence these. Thus, we framed governance challenges as potential institutional mismatches, in terms of structures and processes (Epstein et al. 2015), as well as relating to the possible incoherence of diverse policies, plans, and strategies (Ekstrom and Young, 2009; Benson and Lorenzoni, 2016).

Our case study is set in a multilevel governance context in the Global South, namely in southwestern Ethiopia. Much of the world's biodiversity is found in the Global South (Swiderska, 2008), which also is characterized by both a high prevalence of biodiversity loss as well as food insecurity, poverty, and underdevelopment (Swiderska, 2008). This has been attributed to, among others, institutional problems such as weak institutions (Swiderska 2008), institutional misfit (Brown, 2003; Bodin, 2017), divergent institutional interests (Brown, 2003; Guerrero et al., 2015), and a lack of policy coherence (Duit and Galaz, 2008). Ethiopia provides a highly relevant context to examine the interplay of food security and biodiversity governance because the country hosts a rich but declining biodiversity (Schmitt et al., 2010; Tadesse et al., 2013) and shows high levels of food insecurity (Gove et al., 2008; CSA and WFP, 2014). Drawing on this case study, our objectives were to identify and explain different types of governance challenges (1) *within* the sectors of food security and biodiversity; and (2) for the integration *between* both sectors.

Our study contributes to the research on integrated and collaborative governance approaches to social-ecological systems, which – despite criticism regarding practicability and power relations (Bodin, 2017) – have been widely regarded as contributing to improved sustainability outcomes (Johansson, 2018; Bodin, 2017). In particular, we contribute to two main issues that, so far, have remained under-addressed. First, most studies of governance challenges have focused on single sectors (e.g. on food security or conservation) or particular governance levels (e.g. local or regional levels), or a particular aspect of governance (e.g. structures, processes or policies) (Fanning et al., 2007; Sayer et al., 2013). Such fragmented approaches, however, can only partly explain the complex governance challenges emerging from multisectoral and multilevel governance issues (Epstein et al., 2015). Second, despite theoretical progress, detailed empirical studies that holistically assess different aspects of sustainability governance – structures, processes and policy content – remain scarce (Visseren-Hamakers, 2015; Philip and Rohracher, 2012).

To identify different types of governance challenges, we first provide our analytical framework of governance challenges. This framework draws on a range of governance literature to provide a basic classification for the types of challenges that we identify in our case study. We then outline details of our methodology including data collection and analysis. The subsequent results section is structured according to the types of governance challenges identified, with both objectives (i.e. within and between sectors) addressed for each type of challenge. We conclude the paper with a discussion of the implications for improving sustainability governance.

Analytical framework

We conceptualize governance challenges as problems of institutional mismatch fostering conflicts, hampering potential synergies and affecting the overall effectiveness of governance regimes. Such challenges are discussed in the literature on environmental governance under various labels (see e.g. Visseren-Hamakers, 2015) and focus on various levels of institutional structures and stages of policy making (Nilsson et al., 2012). We tap into this diversity of concepts and categorize governance challenges depending on their occurrence in the governance regime (institutional structure, policy process, policy outputs and instruments), the direction of interactions across governance levels (horizontal vs. vertical), and their inter-sectoral orientation (internal vs. external) (see Figure 5.1 and Table 5.1).

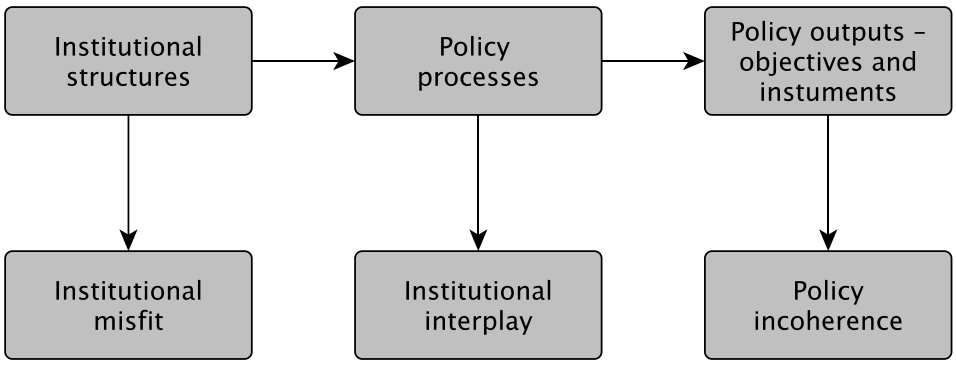

Figure 5.1. Analytical framework to analyze governance regime and associated governance challenges (adopted from Nilsson et al., 2012). Problems related to institutional structures, policy processes and policy outputs typically manifest through institutional misfit, problems of institutional interplay, and policy incoherence. Each of these could occur within and between multiple sectors, and within and between governance levels (see Table 5.1).

Governance challenges in the structure, process or output of governance regimes can be characterized as three distinct issues of interaction: (1) institutional misfit; (2) problems of institutional interplay; and (3) policy incoherence (Fig. 5.1). *Institutional misfit* refers to problems relating to how well institutional characteristics fit with the existing social and ecological characteristics of the system at hand (Young, 2002; Folke et al., 2007; Duit and Galaz., 2008) (Fig. 5.1). While this may include functional, spatial and temporal aspects (Moss, 2012), we primarily focus on the functional dimension, i.e. the misalignment of institutional functions with other institutions and with the wider social-ecological systems (Epstein et al., 2015), and examine whether institutions were capable and mandated to govern the functional interlinkages between food security and biodiversity. Other issues of institutional misfit (such as governance structure and implementation deficit) have been identified and discussed elsewhere (see Jiren et al., 2018).

Problems of *institutional interplay* refer to issues arising from institutional interaction in the process of setting policy, plans and strategies, implementation and evaluation (Young, 2002; Gehring and Oberthür, 2008) (Fig. 5.1), aiming at the delivery of specific, defined governance outcomes (Young, 2002; Paavola et al., 2009). Here, we conceptualize problems of institutional interplay as the patterns of interaction between institutions and the resulting challenges caused in the process of governing food security and biodiversity (see e.g. Leventon and Laudan, 2017). Interactions of institutions take place within and between multiple sectors, and within and between multiple levels of governance (Young, 2002). Horizontal institutional interplay, in this context, refers to the interaction of institutions operating at the same governance level, both within sectors and between them. Vertical institutional interplay occurs between institutions across different governance levels (Young, 2002; Lebel, 2005, Paavola et al., 2009) (Table 5.1).

Policy incoherence occurs when actual policy outputs are not compatible with each other or the related implementation practices, or are contradictory to the problem the policy seeks to address (Nilsson et al., 2012) (Fig. 5.1). Here, we define policy broadly to include strategies, plans, rules, proclamations, and directives relating to the governance of food security and biodiversity. We extended existing notions of policy incoherence, conflict and contradiction between policy elements within a given domain (Nilsson 2012, Candel and Biesbroek, 2016), and identified policy incoherences between the sectors of food security and biodiversity

conservation. Similar to problems of institutional interplay, policy incoherence was understood to occur both horizontally and vertically (Table 5.1).

Table 5. 1. Conceptual framework indicating how governance challenges (institutional misfits, problems of institutional interplay, and policy incoherences) occur across different sectors and levels. The *sectoral dimension* shows whether the governance challenge is within the same sector (internal, i.e. within the food security or biodiversity sector), or the integrated governance of the two sectors (external, i.e. between the sectors of food security and biodiversity conservation). The *administrative dimension* indicates whether the governance challenge occurs between institutions at the same governance level (horizontal) or across governance levels (vertical). (Adopted from Nilsson 2012)

		Sectoral dimension	
		Internal (*within* food security or biodiversity)	**External** (*between* food security and biodiversity)
Administrative Dimension	**Horizontal** (*within* policy level or implementation level)	**A**	**B**
	Vertical (*between* policy level and implementation level)	**C**	**D**

Methodology

Study location

The study was conducted in Jimma zone of Oromia regional state, southwestern Ethiopia (Fig. 5.2). The administrative structure of Ethiopia is organized into five levels: federal/national, regional (state), zonal, woreda (district), and kebele (municipality) administration. Our study included all administration levels but with a focus on Jimma zone. Jimma zone is located approximately 350 km southwest of Addis Ababa and exhibits strong interactions of food security and biodiversity conservation (Ango et al. 2014). Within the zone, considering social-ecological variation such as in altitude, crop diversity, population representativeness, and livelihood strategies, we selected the three focal woredas of Gumay, Gera, and Setema (Fig. 5.2). We further selected, based on the same considerations, six focal kebeles (two in each woreda) namely Kuda Kufi, Bereha Werango, Kella Hareri, Borcho Deka, Difo Mani, and Gido Beri (see Fig. 1.1). Our study involved governmental, non-governmental, semi-autonomous and community-based organizations who affect or are affected by decisions in the food security and biodiversity conservation sectors in the study area.

Data collection and analysis

We collected data from stakeholders involved in the governance of food security and biodiversity conservation through key informant interviews and focus group discussions. We used snowball sampling to identify all stakeholders involved in the governance of food security and biodiversity conservation because such sampling allows the identification of a complete set of stakeholders (Leventon et al., 2016; Reed et al., 2009). Specifically, we employed bottom-up snowball sampling, where local level stakeholders were identified first, followed by stakeholders at higher levels.

During data collection, we first explained the purpose and scope of our study to the kebele administration and local development agents, who then helped us to identify kebele level stakeholders. Here and in all our interactions with stakeholders, we clarified that the food security sector concerned all stakeholders and issues regarding production, access, utilization and stability of access to food. Similarly, we explained that the biodiversity sector involved stakeholders and issues regarding farmland and forest biodiversity. We identified local level stakeholders representing different wealth groups (rich and poor) and geography (geographical household clusters). Second, based on the listing of actors named by kebele level institutions,

we identified woreda level stakeholders. We followed a similar procedure at all governance levels until no new stakeholders were mentioned.

Data were collected through a total of 177 interviews and 24 focus group discussions with the identified stakeholders. Focus group discussions were used to collect information from local people, whereas key informant interviews were conducted with formal governmental and non-governmental institutions. Organizations were represented by their head, deputy head, or senior personnel. Respondents in both formats were asked questions around five main themes: (a) their roles and interest in the governance of food security, biodiversity and the intersection of both, (b) governance challenges associated with the governance of food security, (c) challenges associated with the governance of biodiversity including the dimensions of these challenges, (d) challenges for the integrated governance of food security and biodiversity, and (e) we asked the respondents to list institutions with which they interacted in the governance of food security, biodiversity or both, at either the same governance level or with one level higher.

Consent was obtained from participants, and an ethics approval granted by Leuphana University, to audio record all interviews and discussions. We transcribed the recordings (average duration: ~1 hour) and field notes for all stakeholders. We then organized and entered the transcripts into the qualitative data analysis software NVivo version 11, for the coding of transcripts and subsequent qualitative content analysis. Here, we deductively created three separate nodes, one each for food security, biodiversity and the integrated governance of both. Next, we created sub-nodes under these primary nodes to identify whether challenges occurred along horizontal and vertical governance dimensions. We then inductively created another layer of sub-sub-nodes based on the transcripts, in which governance challenges were classified into different themes that formed the basis for our assessment of institutional misfit, the problem of institutional interplay or policy incoherence. For the sake of simplicity and to represent the discretionary powers and responsibilities of each level, governance levels were simplified into policy level (involving zonal, regional and federal levels) versus implementation level (including woreda and kebele levels).

Results

We present our results according to the types of governance challenges as institutional misfit, institutional interplay and policy incoherence.

Institutional misfit

In the food security sector, overlap of institutional mandates was one of the most recognized institutional misfits, both horizontally within policy and implementation levels, and vertically between governance levels (Table 5.2). On the other hand, an institutional gap posed a serious challenge to biodiversity conservation, and this was notable at the vertical governance dimension (Table 5.2). Institutional instability and weak bridging institutions were two key misfits that affected the integrated governance of food security and biodiversity. These misfits were observed both horizontally within policy and implementation levels, and vertically between them (Table 5.3). We detail each of these misfits in the following.

For food security, the problem of *overlapping institutions* was a functional misfit, in which the mandates and authorities of institutions overlapped to the point of reducing cooperation towards a common goal and instead causing enhanced competition among institutions. At all governance levels, the majority of respondents in the food security sector indicated that multiple operating institutions had intersecting tasks and responsibilities with limited coordination among institutions. It was reported that, for instance, in the last five years, the Bureau of Agriculture and Natural Resource Management – acting at regional level and below – split into five separate institutions, many of which focused on the same aspects of agricultural production within a common jurisdiction. Although respondents from the administration sector bureaus (region and zonal levels) justified the overlapping of institutions as an indication of policy emphasis – namely improving food production – most of the respondents' criticisms indicated that this had resulted in a neglect of non-production aspects of food security such as the economic access, utilization, and stability.

A large majority of respondents reported that problems of *missing institutions or institutional gaps* most strongly affected biodiversity governance (Table 5.2). A typical example was the institutional vacuum for the governance of farmland biodiversity, with existing institutions solely focusing on forest and wildlife. In describing this gap, a respondent at the zonal level stated: *"No proper institutional support was provided to biodiversity conservation in general and for farmland biodiversity in particular".* In addition, an institutional gap was recognized in terms of the spatial coverage of biodiversity conservation. For instance, the Institute of Biodiversity – the main biodiversity conservation actor in the country – was restricted to the policy level, and no specific institution dealt with biodiversity at the implementation level. Associated with this institutional gap, the *misfit of the political system and characteristics of*

the biodiversity system presented another challenge. Respondents reported implementation of national biodiversity conservation policies became challenging because regional states maintain autonomy, which at times were not aligned with the national biodiversity conservation directions. This led to contradictions and gaps in rule enforcement. For instance, a respondent from a policy level institution stressed that: *"Illegal wildlife hunting is widespread in the country, partly because the federal institutions face challenges to enforce rules at the local level, because the local institutions rarely cooperate with us. … the regional states developed their own interests and rarely cooperate with us".*

In addition to the misfits within each sector, two major institutional misfits, namely *institutional instability and weak bridging institutions,* were identified in the integrated governance of both sectors (Table 5.3). A majority of respondents considered that the challenge of *institutional instability*, i.e. the frequent restructuring of institutions in form, mandate, bureaucracies, and number, made it difficult to foster institutional cooperation for integrated governance (Table 5.3). Institutional instability was associated with fragmentation of services and interventions. For instance, one of the respondents explained: "*Owing to the complexity and interdependence of sectors, cooperation of institutions across these sectors and boundaries is essential. However, because of frequent institutional restructuring and instability, forming and maintaining integration is challenging, and as a result, none of previous integration attempts succeeded".* Emblematic in this sense was the recent trajectory of the Institute of Biodiversity. The institution was re-structured and re-assigned to different ministries three times in the last six years, which respondents named as a major cause for poor institutional integration in the governance of food security and biodiversity. In addition, at the implementation level, most development agents reported a high turnover of bureaucrats and personnel, causing a constant climate of instability that ultimately hampered the integrative governance of food security and biodiversity.

Table 5.2. Challenges in the sectorally internal (i.e. *within*) governance of food security and biodiversity in Ethiopia, as identified by stakeholders of the food security sector (FS) or the biodiversity conservation sector (BC), or by both. Challenges that were mentioned by stakeholders occurred along either vertical (↕, i.e. between governance levels) or horizontal (↔□, i.e. between institutions at the same governance level) dimensions of governance, or along both.

Overall challenge	**Specific challenge**	**Sector in which challenge occurs**		**Administrative dimension (horizontal vs. vertical) and frequency of mentions (%)**			
		FS	BC	FS		BC	
Institutional misfit	Overlapping institutions	X	-	↕ 68	↔□ 74	-	-
	Missing institutions and institutional gap	-	x	-	-	↕ 82	-
	Institutional jurisdictional incompatibility	-	x	-	-	↕ 30	↔□ 30
Institutional interplay problems	Poor coordination of institutions within sectors	X	x	↕ 90	↔□ 85	↕ 86	↔□ 86
	Institutional intervention fragmentations	X	x	↕ 52	-	↕ 26	-
	Conflicting interests of institutions	X	x	↕ 68	↔□ 68	↕ 70	↔□ 70
	Poor participation in decision making	X	x	↕ 82	↔□ 42	↕ 72	↔□ 69

	Lack of meritocracy	X	x	↕ 40	↔ 45	-	↔ 45
	Accountability problems	X	x	↕ 37	-	↕ 46	↔ 22
	Uniformity of plans and fit-for-all strategies	X	-	↕ 50	-	-	-
Policy incoherence	Contradiction in policy implementation strategies	X	x	↕ 78	↔ 62	↕ 45	-
	Incoherence between proclamations and rules	X	x	↕ 31	-	↕ 56	-
	Mismatch between policy intent and local conditions	X	x	↕ 70	-	↕ 30	-
	Institutional power mismatch	-	x	-	-	↕ 42	-

Institutional interplay problems

The problems attributed to institutional interplay were similar within and between sectors. Common interplay challenges mentioned related to lacking institutional coordination, institutional fragmentation, and conflicting interests between institutions (Table 5.2 and 5.3). While limited coordination was widespread horizontally both at policy and implementation levels, institutional fragmentation was commonly observed vertically (Table 5.2 and 5.3).

Limited institutional coordination was the most frequently mentioned challenge, describing the failure of institutions to coordinate their plans, strategies, and resources for synergistic outcomes. A large majority of respondents within the sectors of food security, biodiversity, and their integrated governance reported this as an interplay problem (Table 5.2 and 5.3). Reasons for the limited institutional coordination included weak or missing bridging (connecting) institutions (see also above), limited financial and human capacity, and formal disincentives for institutional coordination. At the implementation level, coordination was usually facilitated through the administration sector institutions and through political cabinets such as woreda administration, and woreda councils, whereas sectoral institutions such as the Agricultural Development Partnership and Linkages Advisory Council (ADPLAC, acting at the zonal level)

were responsible for fostering coordination within and between sectors. At the policy level, the regional and national councils of ministers were in charge of the facilitation of coordination within and between sectors. These connecting institutions had a formal authority to ensure coordination across sectors and levels. Despite this, they were incapable in terms of expertise and resources to exercise the vested authority and to appropriately foster coordination between institutions. In this regard, and as a majority of respondents concurred, a respondent at the implementation level described: *"As a political organization, administrative cabinets have limited expertise and professional human resources that acknowledge and facilitate coordination between institutions. Moreover, these structures rarely understand synergies, nor are they willing to foster coordination".* Similarly, ADPLAC was attested to have limited financial capacity and willingness to enhance collaboration, and consequently, most organizations knew of its existence but not its functions. In addition to the inherent weakness of connecting institutions, the performance of individual institutions was evaluated without any concern for coordination, thus providing a disincentive to foster better coordination. An interviewee at the implementation level stated in this context: *"We understand the importance of coordination and are aware of contradictions between different institutions. But we pursue our task since we will be evaluated in terms of our specific task, and there is no point in wasting resources in fostering coordination".*

Similarly, the processes and instruments applied by institutions were described as fragmented, provisional, and even contradictory. These *fragmented institutional procedures and interventions* were found both within and between the sectors, and were mentioned by implementation level stakeholders in particular. The main reported criticism deemed that many interventions were either untimely, discontinued or replaced with other forms of intervention. This situation of procedural insecurity and permanent alteration appeared particularly frequently in the supply of food production technologies and financial services. An interviewee from the implementation level explained: *"Similar to the institutional turnover, interventions are crooked. Regularly, we are forced to adopt different technologies without seeing the feasibility of the previous technology. Sometimes, we are forced to adopt different incompatible technologies over the same period by multiple institutions, which leaves us vulnerable".*

Conflicting interest between institutions was another problem associated with institutional interplay (Tables 5.2 and 5.3). Within the sectors, conflicts of interest were political, and resource-based, whereas in the integrated governance of food security and biodiversity they

were deeply discursive. For example, the Bureau of Agriculture and Natural Resources Management and the Bureau of Coffee Development and Marketing were strongly divided in their ambitions regarding land use: both institutions planned to expand the farmland area for the cultivation of either crops or coffee on the same, finite area of land. Conflicts of interest between food security and biodiversity institutions were deeply enshrined on whether food production should precede conservation or vice versa.

Within a given sector, challenges related to *limited participation*; and *problems of meritocracy and accountability* were also commonly observed (Table 5.2). Implementation level stakeholders expressed concerns that their participation in key decision-making processes around policies, plans, and instruments was negligible. Instead, accountability chains were mainly oriented upwards towards higher levels, largely detached from local populations and contexts. A local farmer explained this with the analogy of *"What comes from above [referring to God as well as the central government], no one dares to refuse or disobey"*. At the same time, a majority of respondents indicated that key decisions were taken without the incorporation of expert knowledge, and bureaucracies were characterized by a serious lack of expertise and capacity. Similarly, *uniformity of plans and one-size-fits-all approaches,* irrespective of biophysical and agro-ecological conditions, represented a widespread institutional interplay problem, especially in the governance of food security, as indicated by about half of the respondents. Irrespective of conditional differences between districts, for instance, plans and strategies for a given institution were uniform across districts, because decisions were made centrally (Table 5.2).

Policy incoherence

We identified three core realms of incoherence within the governance of food security and biodiversity: contradictions in policy implementation strategies, incoherence between proclamations and rules, and mismatches between policy intent and local contexts. These challenges were largely observed vertically between policy and implementation level (Table 5.2).

The national policy strategy on food security, namely the Agricultural Development Led Industrialization Strategy (ADLI) (MOFED, 2010), the Rural Development Policy and Strategy (RDPS) (MOFED 2003), and subsequent Growth and Transformation Plans (GTP I and II) (MOFED 2010), evidently set sufficient production as a means to achieve food security

as their national policy goal. Similarly, the National Biodiversity Strategy and Action Plan (NBSAP) (FDRE, 2005) stipulates the protection and conservation of the country's biodiversity as main policy goals. While these goals were formulated consistently in each sector, we found major *incoherence among the implementation strategies* on how to reach the desired policy goals. In the food security sector, two competing strategies for the organization of farming systems and agricultural techniques were identified. Some of the institutions pursued a strategy that was geared towards the sustainability of social-ecological systems, which favored a smallholder-based, diversified agricultural system (e.g. the Disaster Prevention and Preparedness Commission). Others, in contrast, favored a farming system that aimed to increase local farmers' income through specialized and intensive commercial agriculture (e.g. Coffee and Tea Development and Marketing Authority). Similarly, regarding farming techniques, a labor-intensive farming technique was favored by one strategy based on the country's labor surplus, while another pursued capital intensive, mechanized farming techniques on the ground of farm efficiency. Such incoherent strategies left actors at the implementation level with contradictory options and incentives.

In the implementation of biodiversity conservation, a major contradiction occurred between the nationally-endorsed community-based biodiversity management strategy and a strict biodiversity preservation approach that was mainly propagated by regional forest authorities. These conflicting strategies manifested at the implementation level as incoherent sets of measures and incentives, officially giving communities the right to manage the forest and wildlife in coordination with the government agency through participatory forest management (see Ethiopian Forest Policy 2007), while leaving them largely excluded from resource management decisions and activities in practice.

Incoherencies in proclamations and rules were most prominently observed for land use and land tenure security. These incoherencies occurred in both sectors (Table 5.2). For instance, a regional proclamation (Oromia Rural Land Proclamation, ORLP 130/2007) granted rural people assurance against eviction or expropriation, while also endorsing forced expropriation under certain circumstances. Similarly, on the basis of provisions under two regional proclamations (ORLP 130/2007 and 151/2012), rural people's tenure over their land was secured, while the same texts endorsed coercive land transfer for "unused" land.

Similar incoherencies of proclamations were observed in the biodiversity sector. For instance, expansion of private forestry was supported by the national as well as the regional forest policy

(National Forest Policy 1992, 2007; and Regional Forest Law 2007), while regional proclamations (ORLP 130/1999 and 151/2001) restricted plantations on private farmland. Incoherencies were also found vertically on the irregularities between the different policy contents and actual practices. For instance, the national and regional forest policies and their proclamations (National Forest Policy 2007, Proclamation 542/2007; Regional Forest Law 2007, Proclamation 84/2007) endorsed the establishment of participatory forest management, but no participatory forest management had actually been established within our study area. Similarly, national forest policy (Proclamation Number 542/2007, sub-article 3) also endorsed the protection of endemic tree species (e.g. *Podocarpus falcatus* and *Cordia africana*), while several organizations indicated that these tree species were widely harvested and utilized. Incoherencies extended also to gaps in proclamations and directives. For instance, a regional land use proclamation (ORLP 151/2012, sub. 21/5) restricted the plantation of *Eucalyptus* in the landscape, with details to be determined by further directives. No such directives, however, were produced to specify the conditionality of such plantations at the district level. Due to these conflicting provisions and strategies, implementation-level stakeholders faced considerable institutional uncertainty and socio-economic insecurities.

At the intersection of food security and biodiversity, challenges were largely related to incoherence in policy goals, which manifested both horizontally and vertically. We identified two opposing discourses: the "biodiversity and sustainable development" vs. "growth and local livelihoods" discourses. The former discourse, deeply rooted in the ideas of nature conservation and supported by a national policy document (Climate Resilient Green Economy; CRGE, 2011), argued that *"the basis for sustainable development and ensuring food security relies on the quality of the environment and natural resources we have. Therefore, taking care of biodiversity is a primary goal"* (interview with a senior policy maker at the federal level).

In contrast, the latter discourse, which strongly focused on economic growth and was endorsed by another national policy document (ADLI; FDRE, 2007), was characterized by the words of: *"The primary policy objectives of the nation should be to feed the population using all possible means. Biodiversity conservation needs to support food security"*. This incoherence in discourses was reproduced at the implementation level, leading to conflicts in the integrated governance of biodiversity conservation and food security. National wildlife policy (Ethiopian Wildlife Policy and Strategy, Proclamations 471/2005 and 541/2007) restricted wildlife hunting and population management, which had resulted in an increase of wild animal

populations in the forest. Expansions in particularly baboon (*Papio anubis*) and warthog (*Phacochoerus africanus*) populations, in turn, had then led to increases in crop-raiding and reduced food security among rural communities. Discussants at the implementation level explained: *"I harvest less than a quarter of what I plant, the rest is damaged by wildlife"*.

Table 5.3. Challenges in the sectorally external (i.e. *between*) governance of food security and biodiversity sectors in Ethiopia, as identified by food security and biodiversity stakeholders. Challenges that were mentioned by stakeholders occurred along either vertical (↕, i.e. between governance levels) or horizontal (↔□, i.e. between institutions at the same governance level) dimensions of governance, or along both.

Overall challenge	Specific challenge	Administrative dimension (horizontal vs. vertical) and frequency of mentions (%)	
Institutional misfit	Institutional instability	↕ 28	↔ 60
	Missing bridging institutions	↕ 82	↔ 82
Institutional interplay problems	Poor coordination	↕ 88	↔ 94
	Implementation fragmentation	↕ 67	-
	Structural segregation of sectors	↕ 57	↔ 66
	Development and conservation interest mismatch	↕ 61	↔ 43
Policy incoherence	Mismatch in policy goals	↕ 76	↔ 94
	Focus and bias in policy	-	↔ 42

Discussion

In our study, we identified that sustainable governance of food security, biodiversity and their integration was often constrained by: (1) the misfit of institutional structures and processes with the complexity of social-ecological system; (2) incompatibility caused through various interactions between institutions; (3) incoherence in the content of policies that shape the governance arrangement of these policy sectors. Our study showed that most governance challenges were interrelated and affected not only single policy sectors but also, and often more severely so, the integrated governance of food security and biodiversity. In combination with a range of widely recognized socioeconomic drivers (Hassen et al, 2016), the persisting governance challenges identified in this study probably help explain why southwestern Ethiopia continues to be characterized by food insecurity and biodiversity loss (CSA and WFP, 2014; Hassen et al., 2016; Aerts et al., 2017). Essentially, our three main categories of institutional misfit, institutional interplay and policy incoherence relate to structural, process and policy-content challenges (Philip et al, 2012; Guerrero et al., 2015). In the following sections, we therefore follow this distinction and further discuss how the identified challenges affect sustainability governance, and we provide some implications for the future. While our results are relevant for the improvement of integrated local governance, they also provide important insights into general governance challenges where contrasting sustainability goals are pursued.

Structural governance challenges

A contemporary understanding of sustainability suggests that a misfit between the structural arrangement of institutions and social-ecological systems is a major impediment to sustainability governance (Folke et al., 2005; Paavola and Adger, 2005). Such structural misalignment could occur in a multiple ways (Brown, 2003), for instance, in our case this misfit was observed through the institutional vacuum, and also a concentration of many institutions governing particular aspects of policy sectors (e.g. food production), while other aspects (e.g. food utilization, farmland biodiversity) lacked institutional support. Similarly, although institutional flexibility consistent with social-ecological system dynamics is likely to be beneficial (Paavola et al., 2009), overly frequent change and institutional instability hampered cross-sectoral interactions in our case. Consistent with the findings presented here, other studies focusing on a single policy sector (e.g. water governance, Newig et al., 2016) and multiple policy sectors (e.g. the integrated governance of rural development and conservation

in Romania, Mikulcak et al., 2013) also highlight the importance of managing such structural misfits in the context of sustainability governance.

Often, structural governance challenges are associated with the overall national governance regime. For instance, in a traditional hierarchical governance system such as in Ethiopia (Dejene, 2003; Jiren et al., 2018), maintaining a good fit between governance structures and social-ecological systems is inherently challenging due to a linear command pathway against the complexity of social-ecological system, and limited room for institutional interaction and learning. In addition, failure to acknowledge the interdependence and complexity of social-ecological systems, as well as the misalignment of institutional and biophysical boundaries could result in institutional misfit (Young, 2002; Bodin et al., 2014; Episton et al., 2015). Consequently, structural misfits often result in challenges such as fragmentation, implementation deficits, and policy incoherencies.

Managing such institutional misfit requires designing institutions that holistically and sustainably address multiple policy sectors. This, to a large extent, is contextual and depends on the nature of the social-ecological system at hand. Despite the absence of governance panacea (Ostrom, 2007, Jager, 2016), approaches that try to improve institutional fit should consider a governance structure that fosters collective action, promotes institutional learning and shares resources (Berkes, 2009). Moreover, maintaining stakeholder interactions across governance levels and policy sectors could improve institutional fit (Leventon and Antypas, 2012; Candel and Biesbroek, 2016).

Governance challenges in policy process

In addition to governance structures, the processes of policy making, implementation and evaluation shape sustainability outcomes in social-ecological systems. Problems related to institutional interplay involve multiple types of challenges, among which a lack of coordination and limited stakeholder participation remain two major issues that affect the governance of single as well as multiple policy sectors. For instance, several studies indicate that poor coordination and participation are widely known problems to reduce sustainability in the sectors of food production (Endale, 2011), biodiversity conservation (Agrawal et al. 2008; Kalaba et al, 2013), and wider social-ecological system governance (Thrup, 2000). In our study, in a single policy sector, poor coordination often resulted from institutional routines and decreased the effectiveness of ultimate institutional goals. In other instances, however, poor

coordination can also be caused by structural governance misfits (Bodin, 2017; Jiren et al., 2018). Except for its interactions with institutional structural fit, coordination is also shaped by how power is exercised to foster cooperation across governance sectors and levels. In our study area, multiple powerful institutions held structurally central positions and thus were able to potentially improve coordination between institutions. In practice, however, actual coordination often remains insufficient due to various factors including power capture by some stakeholders (Jiren et al, 2018). Other interplay problems such as the absence of good governance (e.g. limited meritocracy and accountability) could also hamper sustainable governance of social-ecological systems.

We found reasons for procedural governance problems to broadly include structural misfit, limited capacity of bridging institutions, and disincentives for institutional integration. In addition, the strong inward focus of institutions (Bergsten & Zetterberg, 2013) and failure to recognize interdependencies within social-ecological systems (Peters, 2004; Williamson, 1999) commonly cause challenges of governance process. Problems of institutional interplay were often about the institutional attributes and solutions chiefly require improving institutional performance, e.g. through building capacity around collective action, and devising institutional arrangements that integrate heterogeneity and promote coordination. As recognized elsewhere (e.g. Ostrom, 2010; Ribot et al. 2006; Emerson et al., 2012), our results thus encourage the use of participatory and interdisciplinary approaches to governance in social-ecological system to overcome procedural governance challenges.

Policy output challenges

Coherence in the content of policy goals and instruments is not only vital for a successful sectoral policy, but also and particularly so for the integrated governance of multiple sectors. Our findings revealed that food security and biodiversity conservation in southwestern Ethiopia were each characterized by contradictions in sector-specific policy instruments, and that strong incoherences existed in policy goals across sectors. More importantly, we indicated that internally each policy sector struggled with contradictions in the instruments to achieve specific sectoral goals, e.g. incoherencies in proclamations and rules related to specific land uses. At a more general level, however, contradictions and incoherence were about fundamental conflicts in policy goals and strategies, e.g. conflicting discourses on the sequencing of development versus conservation. Such content-related challenges are widely acknowledged as major obstacles for sustainability governance and can severely hamper the sustainable achievement

of development and conservation goals, and more so when it involves interactions among multiple policies (Brown, 2003, Zerbe, 2005, Kalaba et al., 2013, and Nilsson, 2012).

Consistent with our own findings, earlier studies also strongly emphasize that incoherence in policy content can at least partly result from defects in governance structure – for example, a hierarchical structure limits institutional interactions and encourages disciplinary approaches – as well as defects in governance process – such as failure to effectively pursue jointly agreed policy goals (Orsini et al., 2013; Nilsson et al., 2012). Consequently, policy incoherence can lead to governance fragmentation, conflicting institutional goals, and process incompatibility. Thus, it is essential to manage conflicts between policies, and maintain synergies not only between policy goals but also between policy instruments within and across sectors. Based on our findings, and as emphasized in previous studies (Paavola et al., 2009; Nilsson et al, 2012), we argue that a comprehensive approach that ensures participation or coordination of actors from multiple sectors and governance levels is essential to maintain coherence.

Implications and future recommendations

Our study demonstrates that structural misfits, problems of governance processes, and incoherence of policy goals and instruments can pose major challenges for sustainability governance. In addition to hampering individual policy sectors, these challenges reduced the effectiveness of the integrated governance of multiple policy goals – in our case food security and biodiversity conservation. Our findings also suggest that the three issues identified reinforced each other, which further underlines the need for integrated approaches and solutions. While contextual, flexible and adaptive solutions will inevitably be required (Hess and Ostrom, 2007; Jager, 2016), one way forward may be to pursue an integrated approach across multiple governance sectors and levels (Guerrero and Wilson, 2016), sometimes labeled as “collaborative governance” (Ansell and Gash, 2007; Epstein et al., 2015; Johansson, 2018). Collaborative governance can enhance structural fit (Bodin, 2017; Folke et al., 2005), promote the coordination of institutions and participation across interests and governance levels (Berkes and Ross, 2013; Candel, 2014), and lead to improved coordination of institutional actions (Brondizio et al., 2009; Lubell, 2004; Guerrero et al., 2015), and hence greater coherence of policy contents (Nilsson, 2012). Our results further stressed the importance of principles of democratic accountability within such a coordinated approach. In this way, through institutionalized checks and feedback, structural misfits and contradictory incentive structures for actors may be detected and addressed more easily (Birnbaum, 2016).

While collaborative governance holds substantial promise to overcome challenges such as those outlined in this paper, its implementation can be time-consuming, costly and complex (Kark et al., 2015). This requires actors to pay attention to avoiding delays in important decisions and actions and to ensuring a balanced representation of institutions and sustainability issues (Johansson, 2018; Bodin, 2017).

Conclusion

Informed by local to national-level stakeholders, this study identified key governance challenges associated with the structures, processes, and policy outputs in the context of food security and biodiversity conservation in southwestern Ethiopia. Because these governance challenges occurred within and across governance sectors and levels and were also strongly interdependent, attempting to solve particular aspects of governance challenges in isolation seems difficult. Instead, a comprehensive and integrative approach is needed to address these challenges. We recommend three developments to improve sustainability governance: (1) the establishment of a governance structure that fosters interaction among diverse institutions and sectors across multiple layers of governance, and across jurisdictions; (2) the strengthening of governance processes, including accountability structures, that ensure coordination and participation of a wide range of bureaucrats, institutions and civil society stakeholders; (3) the streamlining of policies to improve coherence within and across sectors. Collaborative governance, when carefully adjusted to local contexts, may provide an opportunity to foster integration of governance structures, processes and policy contents, and may thus help to improve social-ecological sustainability.

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Section C: Futures pathways

Chapter VI draws on a participatory scenario planning process to sketch out future development trajectories of the study area, with a focus on food security and biodiversity conservation**.** The scenarios are presented in the following chapter.

Chapter VI

Chapter VI

Reconciling food security and biodiversity conservation: participatory scenario planning in southwestern Ethiopia

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In Review in Ecology and Society

Visualization of the current landscape in the study area (Drawing by Jan Hanspach)

Abstract

Social-ecological systems are complex and involve uncertainties emerging from interactions between biophysical and social system components. In the face of growing complexity and uncertainty, stakeholder engagement with the future is important to proactively manoeuvre towards desirable outcomes. Focusing on the interrelated challenges of food security and biodiversity conservation, we conducted a participatory scenario planning exercise in a rural landscape in southwestern Ethiopia. We involved 35 stakeholder organizations in multiple workshops to construct causal loop diagrams, elicit critical uncertainties, and draft scenario narratives. Jointly, we developed four plausible future scenarios for the study landscape: (1) Gain over grain: local cash crops; (2) Mining green gold: coffee investors; (3) Coffee and conservation: a biosphere reserve; and (4) Food first: intensive farming and forest protection. These scenarios differ with respect to their main social-economic dynamics as well as their food security and biodiversity outcomes. Importantly, three of the four scenarios (i.e. all except "Coffee and conservation: a biosphere reserve") focused on increasing efficiency in agricultural production through intensification, specialization and market integration. In contrast, "Coffee and conservation: a biosphere reserve" was driven by agroecological production methods that support diversified livelihoods, a multifunctional landscape, maintenance of natural capital, a governance system that supports local people, and social-ecological resilience. Similar agroecological trajectories have been advocated as desirable for sustainable development in numerous other smallholder farming systems worldwide. Given fewer trade-offs and better equity outcomes, it appears that an agroecological development pathway stands a good chance of generating synergies between food security and biodiversity conservation; while pathways prioritizing agricultural efficiency are more likely to degrade natural capital and cause social inequity.

Key words: Agroecology, Biodiversity conservation, Drivers of change, Food security, Intensification, Participatory, Scenario planning, Social-ecological system

Introduction

Many agricultural landscapes in the global south face the two interlinked challenges of improving food security while also halting biodiversity decline. Despite a continued increase in global food production over the last years, one in nine people are still considered food insecure (Godfray et al. 2010; FAO 2018). At the same time, the expansion and intensification of agriculture has contributed to biodiversity loss (Foley et al. 2005). The urgency of reconciling food security and biodiversity conservation is greater than ever given increasing pressures from population growth, natural disasters and climate change. This has been globally recognized by including aims on limiting food insecurity and biodiversity loss in the United Nations Sustainable Development Goals (UN 2015). Guidance on how to reconcile these two aims in actual landscapes has, however, been scarce (Fischer et al. 2017). Such guidance in turn should consider that food security and biodiversity conservation are intimately connected through land use practices, livelihoods, and governance arrangements (Chappell and LaValle 2011; Sunderland 2011).

This paper approaches these complex and interrelated issues through a social-ecological, participatory case study in southwestern Ethiopia. Notably, integrating food security and biodiversity conservation poses ecological questions (Green et al. 2005; Fischer et al. 2008; Edwards et al. 2010; Phalan et al. 2011) as well as agronomic ones (Balmford et al. 2005; Rudel et al. 2009; Lemessa et al. 2012). Further, there are also questions related to actor constellation and governance mechanisms (Ostrom 2009; Folke et al. 2016; Berkes 2017), equity (Nyéléni 2007; Pimbert 2009; Wittman et al. 2016; Fischer et al. 2017), as well as numerous feedbacks that cause path dependencies in development (Fischer et al. 2017). Importantly, all of these features are interdependent and involve multiple sectors interacting across multiple scales (Chappell and LaValle 2011; Wittman et al.2016).

Southwestern Ethiopia is an interesting system for answering such questions because it shares many of the social-ecological system properties of other rural landscapes in the Global South – including rapid population growth (Oromiya Bureau of Finance and Economic Development 2012; FAO 2017), ecosystem degradation driven by land use change (Tadesse et al. 2014), and a high level of institutional fragmentation (Gatzweiler, 2005). The landscapes in southwestern Ethiopia are characterized by mixed subsistence farming, including the cash crops coffee and khat, as well as food crops such as maize, teff and sorghum (Jiren et al. 2017). Similarly, the challenges around food security, biodiversity conditions and associated governance

mechanisms are not unlike those in many other developing countries. People in southwestern Ethiopia are food insecure by international standards (Manlosa et al. 2019) – although better-off than in the drier parts of the country (CSA/WFP, 2014). From a biodiversity perspective, southwestern Ethiopia hosts an important share of global biodiversity (Mittermeier et al. 2011), is the origin of *Coffea arabica*, and supports the remaining Afromontane forests of Ethiopia (Chilalo and Wiersum 2011). However, biodiversity loss has been increasing over time (Gove et al. 2008; Hylander et al. 2014; Aerts et al. 2017). In terms of governance, the landscape is characterized by a hierarchical governance structure with government organizations being dominant, high institutional instability, and conflicting development and conservation policies (Jiren et al. 2018). In the last two decades, the country has pursued several different (and sometimes contradictory) policy directions ranging from the promotion of smallholder-based diversified agriculture (MOFED 2003) to commercial and industrial farming (Gebreselassie 2006), and more recently to building a climate resilient green economy (CRGE 2011; Bremes et al. 2015).

Given uncertainties in governance, and rapid social-ecological change, it is important for local stakeholders to engage with possible development trajectories in order to build adaptive capacity and generate shared visions for the future (Freeth and Drimie 2016). To this end, we conducted a visioning exercise, namely participatory scenario planning, with a wide range of local stakeholders. Participatory scenario planning is a method that engages researchers, community and other stakeholders with the aim to elicit plausible future trajectories and, in turn, navigate uncertain futures in complex systems. Participatory scenario planning helps to identify important uncertainties and driving forces that shape current and future changes (Daconto and Sherpa 2010; Hanspach et al. 2014; Oteros-Rozas et al. 2015). Three specific questions guided our study: (1) What are drivers of social-ecological change and how do they interact? (2) What are plausible future development trajectories or scenarios for the region? (3) How do these scenarios influence outcomes related to food security and biodiversity conservation? We discuss our findings with respect to general themes that are relevant to the future of rural landscapes around the world, focusing on social-ecological dynamics and actor and governance constellations that can help to harmonize food security and biodiversity conservation.

Methods

Study area

The study was conducted in Jimma zone, Oromia regional state, southwestern Ethiopia. The population of Jimma zone is approximately 3.1 million people – 10% of Oromia's population, on 5% of Oromia's land (OBFED 2012). Smallholder farmers account for 89% of the zonal population (OBFED 2012). Within Jimma zone, we selected three broadly representative woredas (i.e. districts) for in-depth investigation, namely, Gumay, Gera and Setema. Gumay includes a major town, and relatively intensive coffee production is a main activity in the district, whereas large parts of Gera are covered with forest, and the production of coffee and honey, as well as cattle farming are important livelihood activities. Setema also has large forested areas, but cereal production is more important here. Within each of these three woredas, we purposively selected one kebele (i.e. municipality) – namely Kuda Kufi, Difo Mani, and Kella Hareri.

Study design and analysis

As a first step, we identified stakeholders concerned with issues around food security and biodiversity conservation issues in the study area (Table S6.1). This included local people and their organizations, governmental and non-governmental organizations, and civil society organizations. The identification of these stakeholders was based on a priori knowledge of the landscape, including an in-depth stakeholder analysis previously conducted (Jiren et al. 2017). Based on this, we involved 35 stakeholder organizations, including representatives from the kebele, woreda and zonal levels. These 35 stakeholders represented 29 different types of organizations. Some of the stakeholders were similar at the woreda and zonal levels – e.g. the Bureau of Agriculture and Natural Resources has representations at both woreda and zonal level. The stakeholders represented different aspects of food security such as production, accessibility, finance and economy, marketing, and utilization; similarly stakeholders from the biodiversity sector represented different aspects such as forest and wildlife conservation. Cross-sectoral organizations such as the Women's and Children's Affairs Office, education institutions (including Jimma University) and health offices were also involved. At the community level, local people and their social organizations such as groups of women, men, community leaders, religious leaders (both Muslims and Orthodox Christians), community cooperatives, health professionals and elementary school teachers took part in the study.

Following the identification of stakeholders, we conducted a first round of eight separate participatory workshops. Three stakeholder workshops were implemented at the kebele level, three at the level of each woreda, and two stakeholder workshop were held at the zonal level. These initial workshops were conducted between December-January 2015 and were used to identify the main social, economic and ecological changes of the past 20 years. Also, we collected information on the changes expected to happen in the future. We decided on a 20 year timeframe, rather than 30 or 50 years, because changes in socio-economic and political conditions are rapid.

After identifying key social-ecological variables and changes, we asked participants to identify important drivers and assess their certainty and controllability (Daconto and Sherpa 2010). This exercise yielded 'certain changes' indicating those changes that were expected to happen, and 'uncertain changes' which might or might not happen, or where the direction of change was considered uncertain. Similarly, 'controllable changes' were considered to be under the influence of stakeholders, whereas 'uncontrollable changes' were those over which stakeholders had no control. Finally, participants were asked to identify causal relationships between the drivers as well as their influence on food security and biodiversity conservation. This led to the development of causal effect chains and draft causal loop diagrams.

The collected data from the eight separate initial stakeholder workshops were then analysed by a core team of authors at Leuphana University. The data from the different workshop was summarized and a single integrative causal loop diagram was derived. For that, a summary list of drivers was created sorted by theme (i.e. social, demographic, economic, environmental, technological, and policy-related) and grouped according to the level of certainty and controllability. The resulting causal loop diagram captured the most important and consistently reported variables and relationships as given by the individual workshops. Based on the causal loop diagram we identified key feedback mechanisms, i.e. reinforcing and balancing feedbacks.

Based on this understanding of social-ecological dynamics in the study area, we developed the logic for different future scenarios. The scenario development focused on a subset of the most important as well as the most uncertain drivers of changes, as identified by stakeholders – broadly speaking, these related to land use strategies and agricultural production techniques. Other drivers of change (e.g. climate change, population growth) were also considered in the scenarios, in ways that were consistent with the overall narratives generated. Through this, we developed four internally consistent narratives that plausibly reflected the future of

southwestern Ethiopia. These scenarios were neither predictions of the future, nor do they span the full range of plausible (let alone possible) changes that may take place – rather, the scenarios were representative illustrations of different futures that may emerge in the region, including the extremes along the possible gradients.

After the development of these initial scenario narratives, in February 2018, we conducted six validation workshops with stakeholders who had participated in the initial workshops. This round of the workshop sought to ensure the consistency of scenario storylines, their plausibility, and validity from the perspective of local stakeholders. Based on the feedback obtained from the participants, we refined the scenario narratives. Finally, one author (JH) visualized features of each scenario through stylised paintings that depicted what the landscape might look like in 20 years.

Having generated a complete set of refined and validated scenarios, we conducted a third round of workshops in November 2018, specifically designed to generate impact, that is, to initiate discussions among a wide range of stakeholders about how to best approach the future – given the scenario exercise that had been completed. To this end, we organized a series of workshops at kebele and woreda levels, where we presented the scenarios and distributed posters and leaflets to initiate discussion among stakeholders. In addition, we organized a two-day conference at the zonal level where participants from the local (woredas) and higher levels (zone, region and federal) representing community, non-governmental, governmental, and academic interests participated. In all workshops and at the conference, stakeholders jointly discussed and deliberated on what each of the scenarios implies for the landscape, and discussed what would constitute a desired outcome in terms of integrating food security and biodiversity goals. For this, an open-access booklet (Fischer et al. 2018) was prepared and distributed to the stakeholders to also facilitate discussions beyond the workshops. For the woreda workshops and zonal conference, we prepared a feedback questionnaire for participants, asking them: (a) what they liked and did not like in the process of scenario development; (b) whether the scenario exercise assisted them to think about the future in different ways and if so, how; (c) whether they think that the outcome of the scenario planning process will facilitate further discussion among stakeholders about the future of the landscape. This questionnaire was aimed at understanding the impact of scenario development for local stakeholders. We randomly distributed this questionnaire to 70 participants who all returned it.

Data from this was transcribed and analyzed for its themes using NVivo software. All stakeholder workshops were conducted in the local language, Afaan Oromo.

Results

Drivers of change

We identified a total of 174 drivers that characterized changes in the landscape. These drivers of change were classified as social, demographic, economic, environmental, technological or governance-related, and as certain/uncertain, and controllable/uncontrollable (Table 6.1). Certain and controllable drivers were most prevalent in the social, technological, and political categories (Table 6.1). For instance, *education*, *gender equality* and *employment* were perceived as certain changes that were considered to improve, while other drivers such as *drug addiction* — through increased chewing of khat — were considered to worsen, but perceived as controllable by the stakeholders. In contrast, demographic changes (e.g. *population*) and economic changes (e.g. *coffee market)* were perceived as certain and beyond the control of stakeholders. The most important uncertain and uncontrollable changes spanned a wide range of topics including *local living conditions, social trust and traditions, income, equity and equality, farming system, land use system, forest condition, wildlife population, climate change,* and *land use rights* (Table 6.1).

Social-ecological dynamics

Of the 174 drivers we included the 33 most frequently mentioned ones in a causal loop diagram. The diagram includes the most important links between the variables and with food security and biodiversity (see full diagram in Fig. S6.1). Many variables in the causal loop diagram describe dynamics related to the main livelihood activity, i.e. smallholder farming. At the core of this stands a balancing feedback loop that describes the allocation of land for either food crops (e.g. maize, teff and sorghum) or cash crop production (e.g. coffee, khat and eucalyptus). The balancing effect arises from the fact that farmland is finite. Despite this, yields of both food and cash crops can increase with farm modernization through an increasing application of external inputs such as agrochemicals and inorganic fertilizers (Fig. S6.1), which can lead to higher incomes. Increased income can on the one hand improve financial access to food and thus food security, but on the other hand needs to be reinvested into farming inputs. In this way, the intensification and commercialisation of smallholder farming constitutes a reinforcing feedback mechanism that is further facilitated through improvements in infrastructure, market

access, farmer trainings and cooperative functions. However, this feedback mechanism also leads to biodiversity loss and environmental degradation as well as losses of traditions, knowledge and practices.

Such societal change, in turn, is not only driven by a transformation of the farming system, but also by demographic processes. Human population growth, itself influenced by family planning and women's participation, is a key factor here. Increases in population size and density lead to land scarcity, which leads to conflict over resources, emigration and increasingly prevents farmers from producing enough food. Land scarcity and the increasing need to provide more food lead to the expansion of farmland into forests or traditional grazing land, and thus ultimately to the loss of biodiversity and natural capital. While local traditions and informal social institutions could benefit food security in general, for example by limiting wild animal crop raiding, increasing conflicts and pressures were seen to cause the loss of traditions and informal arrangements. Such informal institutions, however, facilitate participatory resource governance, which was perceived to enhance both food security and biodiversity through collective action, social learning and the empowerment of disadvantaged groups such as women and poor people.

The four scenarios

Based on the key uncertainties (Table 6.1) and social-ecological system dynamics (Fig. S6.1) we developed four plausible scenarios for the study landscape. The scenarios cover a gradient from a stronger focus on producing cash crops to a stronger focus on producing food crops in the area. The four scenarios were termed "Gain over grain: local cash crops", "Mining green gold: coffee investors", "Coffee and conservation: a biosphere reserve", and "Food first: intensive farming and forest protection". In the following section, we present short summaries of the scenario narratives together with visualisations of current and future landscape conditions (Figs. 6.1, 6.2). The full scenario narratives are given in the supplementary online text (Appendix Text 1).

Gain over grain: local cash crops

The Ethiopian government has prioritised farmer specialisation and commercialisation to boost development. As a result, southwestern Ethiopian farmers have abandoned traditional food cropping and focus on cash crops for which biophysical conditions are suitable – coffee, khat and fast-growing trees including *Eucalyptus*. The landscape now consists of intensively

managed coffee forests interspersed with khat and tree plantations, while food production is limited. Farmland biodiversity is dramatically reduced because of simplified habitats and intensive management. Forest biodiversity is also reduced due to intensive coffee management, but forest wildlife still persists. Wildlife raids of food crops heavily impact farmers. Living standards are high for some, but less wealthy farmers and landless people have been marginalised and are worse off now than in the past. Social costs are high: commercialisation through cash crops has reduced traditional cooperative management, khat consumption involves health risks, and mistrust is high within the community.

Mining green gold: coffee investors

International coffee markets and prices have led the government to prioritise southwestern Ethiopia for export coffee production. Large-scale coffee investors have been given land, because smallholder farmers lack the capacities to produce for export. The landscape now consists of monoculture, high-yield coffee plantations, and relatively little food is produced. Both farmland and forest biodiversity have declined strongly because of monocropping and intensive management. Native coffee varieties have disappeared due the influx of high-yield varieties. Farmers have lost land to investors and many received inadequate compensation. Promises by investors of job opportunities and improved public infrastructure have fallen short of local expectations. Poverty, food insecurity, land scarcity and conflicts between coffee investors and local communities have resulted in the emigration of locals. Traditional farming and culture have been lost almost entirely.

Table 6.1. Drivers of change in the study landscape as reported by local stakeholders.

Certain		**Type of driver**	**Uncertain**	
Controllable	**Uncontrollable**		**Controllable**	**Uncontrollable**
Education		**Social**		Local living conditions
Gender equality				Food security
Drug addiction (khat use)				Religious extremism
				Social trust and tradition
Mothers' and children's	Population growth	**Demographic**		
Employment	Coffee market	**Economic**		Income
Coffee productivity				Equity
				Financial access
				Inequality
		Environmental		Farming system
				Land-use system
				Forest condition
				Wildlife populations
				Climate change
				Farm biodiversity
				Food crop productivity
Modernization		**Technological**		
Phone network				
Road network				
Democracy		**Governance**		Land-tenure
Participation in decision-making				Social security and conflict

Coffee and conservation: a biosphere reserve

Conventional agriculture in Ethiopia has failed due to land degradation, and has been replaced by sustainable approaches. Global interest in sustainably grown coffee is increasing. A biosphere reserve has been established that combines sustainable agriculture, eco-coffee production and tourism opportunities. The landscape around a core area of sustainably managed forest consists of a mosaic of diversified farmland and forests. Farmland biodiversity has recovered due to varied habitats and sustainable agricultural practices. Forests and wildlife are managed by the community, and forest biodiversity is relatively high. All people including the poor produce their own food as well as products for export, supported by a revival of traditional cooperative farming arrangements. Economic growth is slow but steady and equitable, and living conditions slowly improve. Household resilience is high due to strong social capital, diversified farming and new income opportunities from tourism.

Food first: intensive farming and forest protection

The government has pushed for commercialised food production in southwestern Ethiopia and has protected existing forests to meet its global commitments. Climate change has made coffee production unviable in the southwest, and food production elsewhere in the country is also failing. Large amounts of food (primarily for sale within Ethiopia) are now produced in the southwest through intensive, large-scale agriculture. The landscape consists largely of fruit and vegetable plots, maize and teff fields in the wetlands, and pastures for beef fattening. Remaining forest areas are strictly protected and not accessible to locals. Farmland biodiversity has plummeted due to intensive management, but forest biodiversity remains high. Some farmers are better off, but poverty is widespread among those who lost land and could not capitalise on new agricultural opportunities – their food security is low. Community resilience is limited due to fluctuations in climate and markets, and many poor people emigrate to urban areas.

Food security and biodiversity outcomes in the scenarios

Each scenario generated specific outcomes for food security, biodiversity, and their integration. For food security, the scenarios differed with regard to availability of food, financial accessibility, and dietary diversity. The “food first” scenario provided the best outcome in terms of food availability and financial capacity because local people produce food crops for consumption and market surplus to generate income. In contrast, the “mining green gold”

scenario provided the lowest food availability, and local people's financial capacity to access food was also low because economic returns from coffee primarily benefitted external investors (Table 6.2). The "gain over grain" scenario increased smallholders' financial incomes. However, the focus on commercial crop production limited food crop availability in the landscape. Finally, the "coffee and conservation" scenario enabled food availability and dietary diversity because in this scenario, local people produced diverse food crops for their own consumption; and food accessibility was most equitable in this scenario (Table 6.2).

For biodiversity conservation, the coffee and conservation scenario provided the best outcome, because the biosphere reserve provided habitat for forest species through a strictly protected core area, as well as habitat for farmland species in a heterogeneous and ecologically managed agricultural landscape. In contrast, agricultural intensification through the application of agrochemicals and artificial fertilizers, improved seeds, and landscape homogenization resulted in the loss of farmland biodiversity in the other three scenarios. Forest biodiversity was partially maintained in the "food first" scenario because of the strict protection of forest remnants. Intensified coffee management practices caused the loss both of farmland and forest biodiversity in the remaining two scenarios (Table 6.2).

The mining green gold scenario threatened local people's food security as well as biodiversity conservation, and thus provided a lose-lose outcome for food and biodiversity. The "food first" scenario, in contrast, provided some benefits for both food and (forest) biodiversity, but the biodiversity benefits were partly offset by intensive land use practices outside the protected areas. Through the implementation of land use zoning, the "coffee and conservation" scenario provided a win-win situation where both food security and biodiversity conservation benefitted. Finally, the "gain over grain" scenario benefitted food security through increasing the incomes of smallholder producers, while intensive production on the farmland and within the forest threatened biodiversity conservation (Table 6.2).

Table 6.**2.** Outcomes of scenarios: Individual outcomes and integration of food security and biodiversity conservation in each of the scenarios. An asterisk indicates that those households who can afford to produce cash and food crops for markets obtain high financial incomes, whereas landless and poor people get poorer in terms of financial income under these scenarios.

Scenarios		**Gain over grain: local cash crops**	**Mining green gold: coffee investors**	**Coffee and conservation: a biosphere reserve**	**Food first: intensive farming and forest protection**
Key features and outcomes					
Food security	Food availability	Medium to high	Low	Self-Sufficient	High
	Access and financial capacity of households	Low to high*	Low	Moderate to high	Low to high*
	Dietary diversity	Low	Low	High	Low
	source and type of food	Purchased food	Purchased food or food aid	Local production and food sovereignty	Processed food from markets
Bio-diversity	Farmland	Decline	Decline	Maintained	Decline
	Forest	Decline	Decline (incl. local coffee varieties)	Maintained	Partially maintained
Integration approaches		Some unintentional integration through agroforestry	No integration	Multifunctional mosaic landscape	Land sparing approach

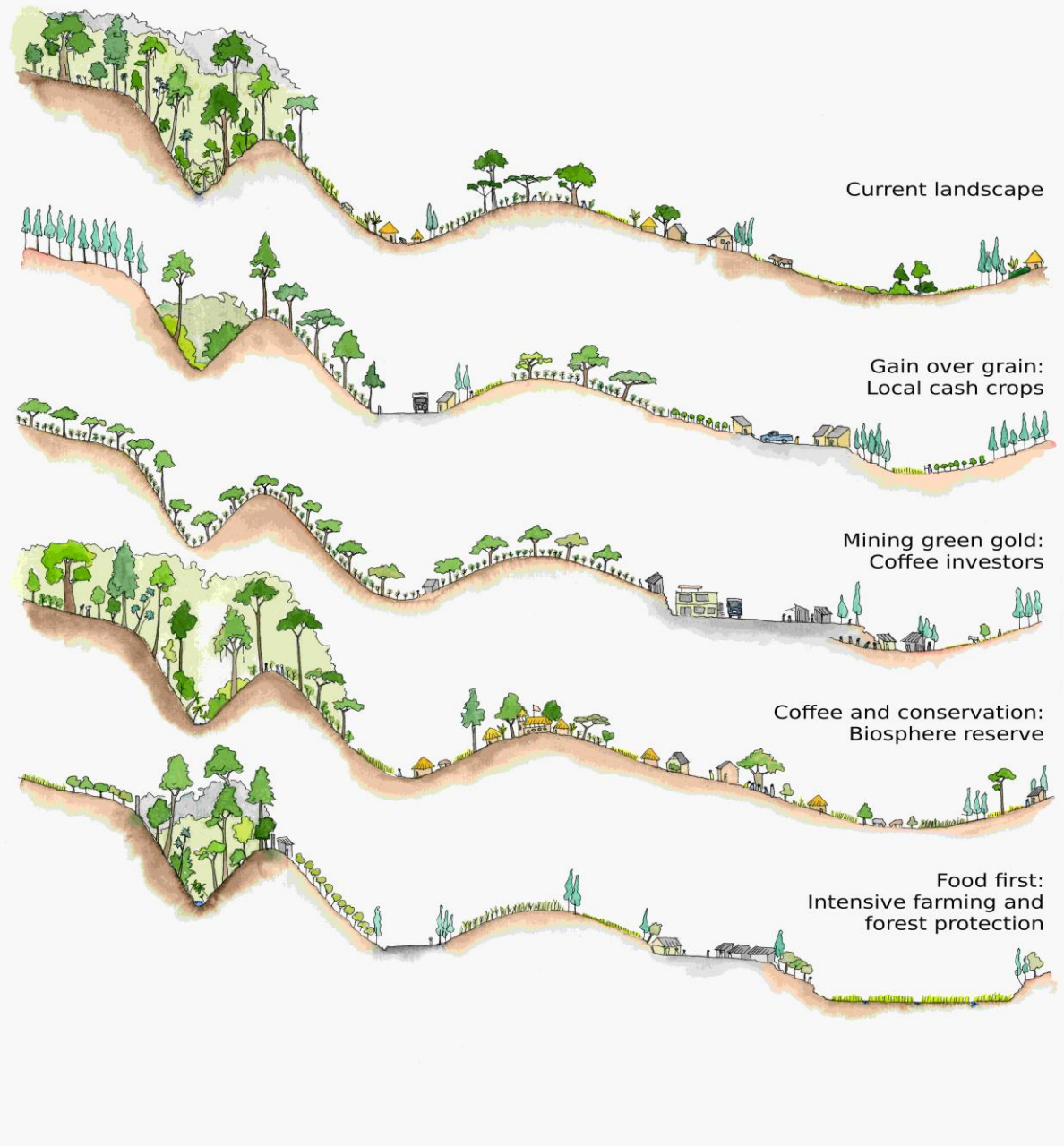

Figure 6.1. Landscape view at present and in the four scenarios. The current landscape consists of a mosaic of food crops, cash crops, pasture, forest and settlements. "Gain over grain" consists of a landscape covered by different cash crops, while the landscape in "Mining green gold" is dominated by intensive coffee plantations. The "Coffee and conservation" scenario is similar to the current landscape in that different crops, trees and settlements coexist. The "Food first" scenario consists of a landscape where intensively produced food crops cover farmland, while forestland is spared and strictly protected from human access.

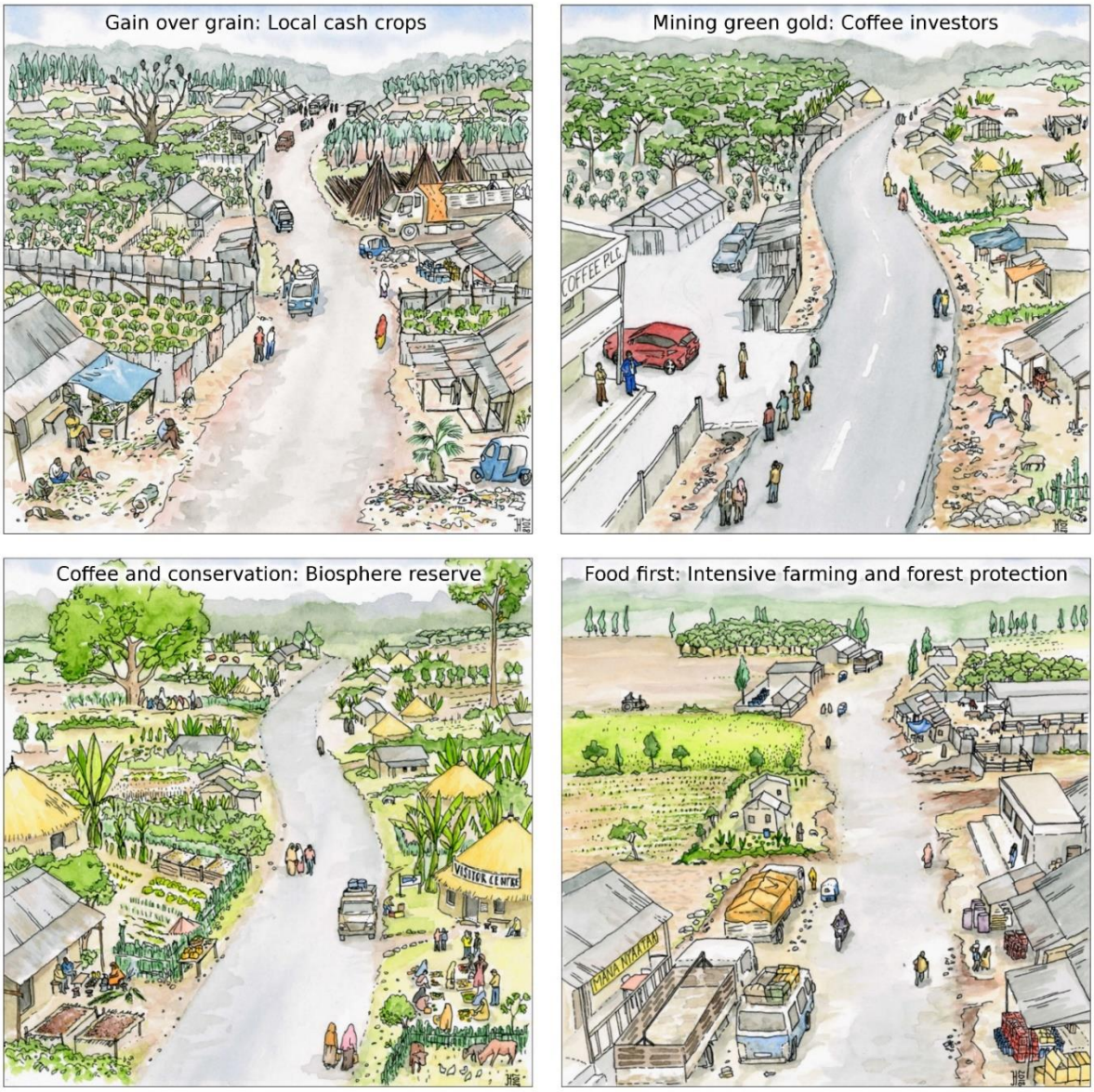

Figure 6.2. Visual representation of the key features of the four scenarios in terms of landscape features and composition in a village. The "Gain over grain" scenario is characterized by a landscape consisting of coffee, khat and eucalyptus, with settlement areas providing local markets for these cash crops. Infrastructure such as roads to the investment area is improved, and the landscape harbours coffee plantations in the "Mining green gold" scenario. Traditional lifestyles where settlements are interspersed with forest and diverse crops characterize the "Coffee and conservation" scenario. Areas of consolidated and intensively used farmland, fruit tree plantation and intensive cattle raising characterise the "Food first" scenario.

Stakeholder perceptions of the scenario development process

All stakeholders positively evaluated the overall scenario development process. Six aspects of the scenario development process were considered most important by the respondents. First, the majority of participants at the woreda and zonal levels (88%) mentioned that they liked the overall organization including the timing and facilitation of workshops and conferences, and the distribution of outreach material. For example, one woreda respondent indicated: "The distributed scenario materials will help us to continually remind ourselves and guide our actions and services accordingly". Second, the majority of respondents (87%) liked that the process of scenario development was inclusive towards stakeholders from multiple sectors. Third, 84% of respondents liked that the scenario development process provided new perspectives and helped them being prepared for the future. Here, one respondent stated: "Every year we develop a future plan in the form of annual and mid-term five years plan. However, this scenario process showed us a holistic and broader picture of the future of our landscape". Fourth, some participants (60%) liked that the scenario development was a joint undertaking and not as extractive as conventional academic research. Fifth, approximately half of the respondents (51%) valued the time allocated to group discussions where stakeholders deliberated on the drivers, scenarios, pros and cons of the scenarios and reported back to the entire group afterwards. Sixth, some stakeholders (42%) appreciated that the zonal conference brought together stakeholders from the policy level (federal, regional, zonal) and implementation level (woreda).

In contrast, stakeholders mentioned two issues that they disliked, or that could be improved in the future. First, 33% of respondents indicated that the scenario development process should not end at this stage, but that there was a need for continuing to engage with stakeholders and plan which steps towards a desirable future should be taken. Second, 19% of respondents indicated that the number of kebele participants, including local farmers, should increase in the future.

Regarding long term impact, stakeholders replied that the scenario planning process would help them to think about the future of their landscape and the need of integrating food production and biodiversity conservation (67%) and that it would facilitate future discussions and cooperations (56%). However, 19% of respondents did not believe the process could bring together stakeholders in the future, because, to foster stakeholders' joint work, a further step of discussing the specific implications and actions would be required.

Discussion

Participatory scenario planning can serve as a tool to explore development pathways of complex systems and thus help to inform planning for sustainable development (Flynn et al. 2017). Here, we implemented such a process and developed a set of exploratory future scenarios for southwestern Ethiopia, an area that is characterized by smallholder farming, rapid population growth and fast environmental change. The resulting future scenarios differ with respect to their main social-economic dynamics as well as their food and biodiversity outcomes. The process of scenario planning provided a structured process for stakeholders to engage with the long-term future, to explore the effects of uncontrollable and uncertain changes and to elicit how certain actors and policies or governance settings may influence future change (Daconto and Sherpa 2010). In the following sections we discuss our key insights about social-ecological dynamics, outcomes and future strategies for the study area and beyond.

Social-ecological dynamics

Disentangling the dynamics of social-ecological systems is a prerequisite to identify levers of change and thus to successful manoeuvre future developments (Meadows 1999). The dynamics of social-ecological systems are often characterized by a small number of feedback mechanisms that determine sustainability outcomes (Walker and Salt 2006). Here, we discuss the key feedbacks observed in the different scenarios.

Most importantly, three of the four scenarios (i.e. Gain over grain, Mining green gold, Food first) were driven by a reinforcing feedback loop around increasing efficiency in agricultural production through intensification, specialization and commercialization. In general, this feedback mechanism can lead to increasing profits, which can benefit food security, but which also need to be re-invested into further inputs such as agrochemicals, machinery or seeds. Current policies of the Ethiopian government strongly support this dynamic as it is seen as one of the key pathways to rural development (MOFED 2010). At its core this strategy follows the logic of the green revolution, which is currently guiding development of the farming sector in order to boost financial income as a means to achieving food security all over Africa (Govereh et al. 1999; AfDB 2014).

The differences between the three scenarios involving such a green revolution type of modernization show that this feedback mechanism can lead to different social-ecological outcomes depending on crop choices and the specific actor and governance constellations. It

shows the range of possible development options available and demonstrates the uncertainties of future developments. While market mechanisms are the main mode of governance in these instances, the additional policy settings and differing emphasis on certain actors steer the system into different directions. This is most obvious in the "Mining green gold" scenario, where poor land tenure rights, prioritization of national revenues, and the influence of external agricultural investors lead to a type of "land grabbing", which would largely exclude local people from the financial benefits of development. Such development has been reported for other parts of Ethiopia (Rahmeto 2011), and, to a much smaller extent, in Jimma Zone (Ango 2018). In contrast to this strong influence of external actors, in the other two scenarios local people are able to exert agency and drive economic development.

Notably, the strong reinforcing feedback mechanism built into a green revolution type pathway has a series of strong negative effects on some social and ecological variables. First it creates social injustices – this is most obvious in the "Mining green gold" scenario, but also in the other two cases, which also see rising inequalities and the loss of traditions and local knowledge. Second, land use intensification leads to the decline of biodiversity both in farmland and in the forest. This happens directly through habitat loss because of the expansion and consolidation of farmland but also through increased application of agrochemicals. This side-effect of modernized conventional farming has been a strong contributor to global biodiversity loss (Grau et al. 2008; Gonthier et al. 2014). While biodiversity loss is partly being counteracted through strict protection of some of the remaining forests in the "Food first" scenario, biodiversity benefits may be minimal or absent in practice because increased agricultural profitability could encourage further agricultural expansion (Matson & Vitousek, 2006; Desquilbet et al. 2016).

In contrast to these three scenarios, the "Coffee and conservation" scenario is driven by a very different dynamic. It is based on the reinforcing mechanism of agroecological production methods increasing natural capital, which in turn, provides diverse and resilient harvests, a wide range of ecosystem services and enhances the long-term sustainability of the landscape. This dynamic is based on a strong emphasis on local agency and participation, and it integrates different land use strategies within a multifunctional landscape. Besides smallholder farmers, it includes non-governmental and other public green niche organisations as important actors. The governance mechanisms are collaborative, involving multiple sectors and levels. Overall, this scenario strongly resonates with the agroecology paradigm (Altieri et al. 2012; Kremen

2015). This approach is also represented by many other farming systems in the world such as the Satoyama landscapes (https://satoyama-initiative.org/about/). Importantly, implementing this development pathway would not necessarily require radical changes in southwestern Ethiopia, but resonates with the culture and traditions of small-scale farming, which makes it much easier to achieve than for example in many wealthy countries of the global North. However, key challenges could be the navigation of power devolution, and the implementation of participatory management and capacity building.

Trade-offs and synergies for food security and biodiversity conservation

Identifying synergies for food security and biodiversity conservation is a key challenge for research and policy (Brussaard et al. 2010; Fischer et al. 2017). In this section we discuss the outcomes of the different scenarios and how these relate to each other. A clear trade-off was apparent in the three intensification scenarios, most strongly in the "Gain over grain" and "Mining green gold" scenarios. Here, increasing agricultural production leads to an overall increase in food security, but at the cost of biodiversity in farmland and forest – a typical trade-off that has been described for intensively used landscapes around the world (Fischer et al. 2017). Overall, the strong emphasis on economic development not only affects biodiversity (Cunneyworth 2001; Holt-Giménez and Altieri 2015; Konstantinidis 2013), but also leads to a loss of resilience to climatic and market shocks (Koohafkan et al. 2012; Fischer et al. 2017). While in the short term, intensification and specialization practices could increase income through national and international market integration, they are also associated with risks of crop losses and market failure, which may particularly threaten the future of smallholder farmers (Pender and Dawit 2007; Gebresillasie and Sharp 2008). Importantly, it is not only the increased susceptibility to shocks that would be unevenly distributed, but also the actual economic benefits and corresponding gains in food security. Intensification, commercialization and specialization could benefit either richer locals or external investors because the majority of poor smallholder farmers would lack the capacity to intensify production and integrate into both domestic and global markets (Jiren et al. in review). Research elsewhere, for instance in other parts of Ethiopia (Rahmeto 2011, Horne et al. 2011), in other sub-Saharan African countries (Cotula et al. 2009) or in South American and Southeast Asian countries (Zoomers 2010, Visser and Spoor 2011), has indicated that few capable actors benefit from market integration whereas often, the majority of poor smallholders may suffer further deprivation.

A clear synergy for food security and biodiversity conservation can only be identified within the "Coffee and conservation" scenario, in which people and biodiversity would both benefit from the pro-active management of social-ecological interactions (Morrison and Fitzgibbon 2014; Holt-Giménez and Altieri, 2015; Kerr et al. 2016). While this scenario would lack the rapid economic development that is inherent to the other scenarios, it would provide a system that is more resilient to environmental and economic shocks, thereby providing a more sustainable long-term perspective for the area.

This synergy is grounded not only in diversification and modern agroecological techniques, but also in clear acknowledgement of the link between food security and social justice through the emphasis on local knowledge and institutions, and the implementation of food sovereignty (Patel 2009). Similarly, in a study in Tanzania, Mbunda (2013) attributed food insecurity primarily to a system guided by a capitalist policy narrative, emphasizing the necessity of re-focusing on a system that nurtures principles and practices of food sovereignty and agroecology. Also, when comparing different cases of a win-win scenario in other systems, some common features are similar to those identified here. Often, win-win scenarios build on empowering smallholder farmers (Holt-Giménez and Altieri 2015; Fischer et al. 2017), focus on agroecological practices and diversified farming (Holt-Giménez and Altieri, 2015; Kerr et al. 2016), emphasize adaptive governance of interdependent social-ecological systems (Morrison and Fitzgibbon 2011), value local knowledge, culture and traditions, ensure smallholder participation both in production and conservation activities (Altieri et al. 2012; Glamann et al. 2015; Ian and Louise 2016), and promote enhanced resilience capacity of smallholders (Tengo and Belfrage 2004; Bacon et al. 2012).

Implications

Global discussions are polarized as to whether economic gains (e.g. efficiency in production, trade and profit maximization) or social-ecological system considerations (e.g. food sovereignty and agroecological production systems) are better suited to integrating food security and biodiversity conservation (McKeon 2015). In this study, a clear synergy was identified for only one of the scenarios. Prioritizing desirable future outcomes is a key requirement to developing and implementing appropriate strategies and policy options (Henrichs et al. 2010). Importantly for this, development trajectories are strongly influenced by specific actor constellations and governance mechanisms (Adger et al. 2005). Our study shows that not only the national and zonal policies and their implementation, but also the role

of local actors will shape the future of southwestern Ethiopia. A sustainable transformation of Ethiopian agriculture, such as described by the "Coffee and conservation" scenario, would benefit from an empowerment of local communities, green niche organizations and environmental NGOs (Järnberg et al. 2018).

Although this study aimed to explore longer term social-ecological changes, it did not look at the dynamics beyond the timeframe of the study. Most importantly, this includes the dynamics of human population growth, which most likely will be ongoing for many decades. Population growth is one of the most important drivers of change not only in our study area but many other parts of sub-Saharan Africa (United Nations, UN 2015). We incorporated some demographic aspects in our study within a 20-year time frame (e.g. emigration to towns, and the need for strengthening family planning). Within the time frame of our study, however, the negative effects of unhindered population growth and emigration remained somewhat hidden. Especially when looking beyond a 20-year horizon, increased attention to the use of family planning and female empowerment, for example through education, become extremely important.

Conclusion

Our study produced narratives of four plausible future trajectories, with different outcomes for food security and biodiversity conservation. The four trajectories differ in their system properties, such as land use strategies, actor constellations and governance mechanisms, as well as in the feedback mechanisms that drive the dynamics of a given scenario. Our discussion suggests that elements of these trajectories may in fact be archetypical – that is, they are likely to apply in similar ways to many other landscapes worldwide. If this is true, the most plausible means to integrate food security and biodiversity conservation is to follow a locally grounded, agroecological development route – including diversified land use, a mixture of cash and food crops, smallholder engagement, and collaborative governance that integrates actors from multiple sectors and governance levels.

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Supplementary Material

Table S6.1. List of stakeholders who participated in the scenario workshops

S.No.	Name of stakeholders	Administration level	Types of stakeholders
1.	Oromia Forest and Wildlife Enterprise	Zone	Government
2.	Jimma University		Government
3.	Bureau of Agriculture and Natural Resource Management	Zone	Government
4.	Land Administration and Environmental Protection	Zone	Government
5.	Disaster Prevention and Preparedness Commission	Zone	Government
6.	Irrigation Development Authority	Zone	Government
7.	Women and Children's Affairs office	Zone	Government
8.	Oromia Forest and Wildlife Enterprise	Woreda	Government
9.	Bureau of Agriculture and Natural Resource Management	Woreda	Government
10.	Land Administration and Environmental Protection	Woreda	Government
11.	Disaster Prevention and Preparedness Commission	Woreda	Government
12.	Irrigation Development Authority	Woreda	Government
13.	Women and Children's Affairs office	Woreda	Government
14.	Office of Livestock and Fish Resource Development	Woreda	Government
15.	Health Office	Woreda	Government
16.	Cooperative Promotion Agency	Woreda	Government
17.	Trade and Market Development Office	Woreda	Government
18.	Japan International Cooperation Agency (JICA)	Woreda	Non-Governmental
19.	Finance and Economic Development Office	Woreda	Government
20.	Administration office	Woreda	Government
21.	Micro and Small Enterprise Development Agency (IMX)	Woreda	Government
22.	Administration and Security Office	Woreda	Government
23.	Oromia Credit and Finance Share Company (WALQO)	Woreda	Government
24.	Rural Road Authority	Woreda	Government
25.	Arga Farmers Union	Woreda	Community Union
26.	Female farmers group	Kebele	Government

27.	Agricultural and Natural Resources Development Agents (Development Agents)	Kebele	Government
28.	Health Extension	Kebele	Government
29.	Religious leaders	Kebele	Community
30.	Kebele leaders (municipal leaders)	Kebele	Government
31.	Jawi Multi-purpose Community Cooperative	Kebele	Community cooperative
32.	Male farmers group	Kebele	Community
33.	Community Network Leaders (Gare	Kebele	Community
34.	Land and Environmental Protection Development Agent	Kebele	Government
35.	Elementary school teachers	Kebele	Government

Table S6.2. Key features of the four scenarios**.**

Feature	**Gain over grain: local cash crops**	**Mining green gold: coffee investors**	**Coffee and conservation: a biosphere reserve**	**Food first: intensive farming and forest protection**
Connectedness (outside landscape)	high to national market	high to global market	medium- to global and national green institutions	high to national market
Main governance mechanism	Smallholder Commercialization (national Market)	market based economy via import substitution and export promotion (global market)	smallholder sovereignty and green economy (bottom-up participatory)	smallholder intensification and regional market integration with state intervention
Main actors	Local community, merchants, extension agents.	domestic as well as foreign investors with big capital	community-based institutions, green-build NGOs, extension workers	input marketing companies, cooperatives
Maintaining feedbacks	Commercialization, and Profits	economies of scale, profit and efficiency	improved natural capital, values	intensification, modernization and profit
Strengths	improved living standards, infrastructure and public services	national export earning, , infrastructural and service development, employment	sustainable development, resilience, and social justice	Improved food supply, smallholders income, forest protection
Weaknesses	inequality, market dependence rice fluctuation, mono-cropping and less resilience	Low resilience to market fluctuations and climate change, decreased social and natural capitals	slow economic growth	loss of natural capital, lack of resilience, lack of food diversity

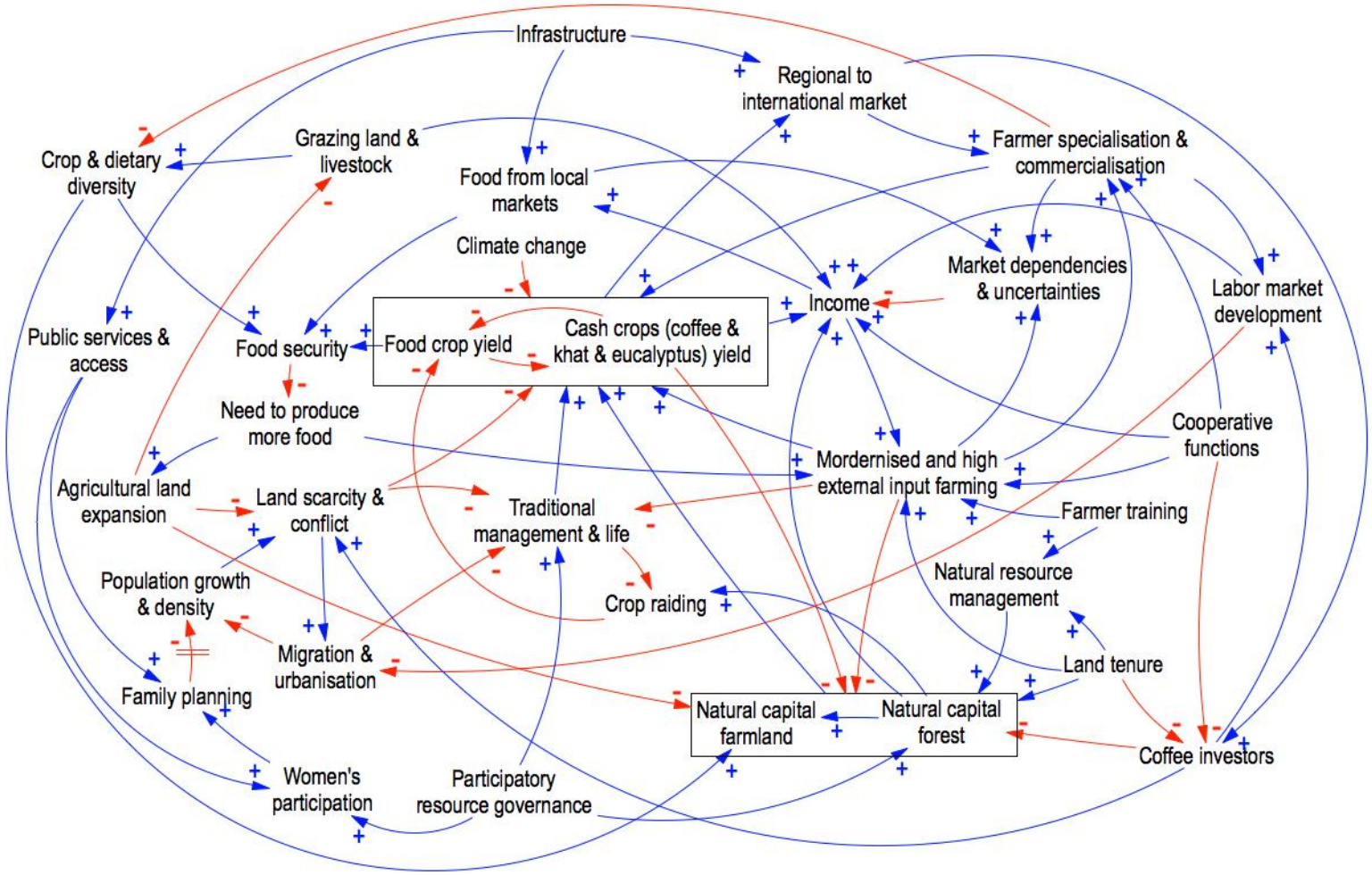

Figure S6.1. Causal loop diagram indicating how variables in the system affect one another. Blue arrows show reinforcing links whereas red arrows show balancing links between the variables.

Appendix text 1: Full description of the scenarios

Gain over grain: local cash crops

Following international calls for agricultural development and national agricultural policy strategies, the Ethiopian government focuses on farmer commercialisation and specialisation as a pathway to increase economic returns and surplus production from smallholder agriculture. While in other parts of Ethiopia the focus is on food production, in the southwestern region farmers are encouraged to increase coffee production. Legal and environmental concerns prevent the government from also supporting other major cash crops, such as khat and fast-growing trees like *Eucalyptus*, but a lack of law enforcement and thriving markets have caused the expansion of these crops nevertheless. Actual crop choice often is rather opportunistic, and rapidly growing rural and urban populations further increase the demand for cash crops. Throughout the region, major investments have been made to improve road and railway infrastructure to allow market expansion and access.

The landscape now consists of large plots of intensively managed coffee forests interspersed with khat and tree plantations throughout the former farmland. The coffee forests are intensively managed, especially through regular clearing of undergrowth and heavy use of agrochemicals. While the coffee forests still provide some refuge to wild biodiversity, management practices have resulted in a stark loss of plant species and wildlife compared to the past. Khat plantations on former farmland are intensively managed as well. Tree plantations, most prominently monocultures of *Eucalyptus*, but also other fast-growing species such as *Grevillea* or *Cupressus*, are widespread, and in some places bamboo and native trees are also cultivated. The plantations of exotic species have severely impacted soil quality and lowered water tables in the landscape, which has made the area not only more susceptible to droughts but also made large areas unsuitable for agriculture. Farmland biodiversity has plummeted dramatically, because khat and tree plantations provide habitat to very few native species. Baboons and monkeys, however, still live in the forests and use farmland tree plantations for shelter; the animals' frequent raids of homegardens and small fields pose a serious problem to the remaining crops, especially for poor farmers who rely on their own food production.

Live fences in the farmland protect the valuable cash crops from theft or destruction. Very little space remains for cultivating cereal crops, and few farmers have maintained small fields or homegardens for cereals. These small parcels for gardening and cropping are vital for the poor, because their lack of land and economic resources has excluded them from the cash crop boom and has limited their access to forest ecosystem services.

Overall, households have benefited from increased incomes and higher (material) living standards – almost all houses now have metal sheet roofs. Infrastructure and public services have improved, more children complete secondary school, and the overall population is becoming more educated. While many people are driven to emigrate from the southwest due to the growing population, increased education and knowledge have decreased population growth rates. Imported food from outside the region is now available at relatively cheap prices. Overall food security is high and people's diets now often include industrially processed foods including meat and dairy products. However, uncertainties remain in periods of drought and due to market price fluctuations. Social costs, in contrast, have been very high. There is a high degree of inequity, and poor people unable to seize cash crop opportunities are even poorer now. The increase in khat production also enhanced khat consumption leading to conflict, crime and a decline in community spirit. Theft of valuable cash crops is common, and there is a high degree of mistrust among the local community. The shift towards a cash-based society has led to the collapse of traditional institutions such as collaborative farming and guarding, and farmers now have to make large investments in human capital to manage and guard their cash crop plantations. Despite better health infrastructure, there are health problems caused by excessive khat consumption and the widespread use of pesticides, which affects food, air and freshwater quality.

Mining green gold: coffee investors

Ethiopia has shifted its focus towards large-scale commercial farming and the export of products to enhance agricultural development and national economic growth. Coffee is the primary export commodity. Due to climate change, there has been a global decline in the supply of coffee, and international demand and market prices for coffee have increased. Because of these conditions the government defined large-scale coffee production destined for the international market as the prime development priority for the region. Because the smallholder coffee production system is fragmented and because smallholders lack capital and institutional support to produce coffee for export, large-scale investors are given priority. Smallholder,

communal and forestland conducive for coffee investment have been transferred to capital investors for the expansion of large-scale intensive coffee plantations.

The landscape is largely transformed to a coffee production zone, with monocultures of high yielding improved coffee cultivars. Large areas of natural forests and farmland have been converted into intensively managed shade coffee plantations, often using non-native shade tree species. Forest biodiversity and ecosystem services have declined rapidly, and it is becoming increasingly difficult for local people to access important forest products. Large-scale forest degradation and hybridisation with the new coffee varieties have destroyed the wild gene pool of *Coffea arabica*. As intensified coffee plantations have expanded into farmland, very little land is left for crop production. Local farmers are left to farm marginalised areas unsuitable for large-scale coffee plantations such as on steep hills and in homegardens. Farmland biodiversity has decreased immensely as a result of the expansion of intensive coffee plantations. This has reduced smallholder farmer opportunities even further – for example, there are too few bees left for honey production. Furthermore, the increased use of agrochemicals for intensive coffee production and the expansion of coffee processing has led to polluted soils, groundwater, and rivers.

Due to the expansion of large-scale coffee plantations land has been transferred from local farmers to investors. Although farmers have been offered compensation for their farmland, this compensation has often been inadequate to make a living afterwards. Furthermore, community participation is tokenistic, and the investors do not live up to their initial promises of transferring skills, knowledge and technology to local communities. People's livelihoods have shifted from being subsistence-based towards employment as the major source of income. Employment opportunities mostly consist of daily labour at the coffee plantations. Job security is low, and often, jobs are given to non-locals. Infrastructure improvements have largely benefited investors, for example through better roads, while improvements in public services such as schools, health centres and other social services have been much more limited.

The transformation from semi-subsistence farming to large-scale coffee production has left many people landless, and vulnerable with little resilience to cope with shocks. The low wages received from labour have increased poverty among the local population. Decreased living standards and loss of land are causing major conflicts between local people and investors. Food security is mainly ensured through what can be purchased from the market. The low financial capital of people reduces dietary diversity and food security. Land scarcity, a general lack of

opportunities, and a growing population, cause mass emigration from the countryside to towns, cities and countries abroad. Overall, social capital is very low. Traditional farming culture has been lost, and the majority of people have no idea how to cope with the change in livelihoods and population growth other than by leaving the area.

Coffee and conservation: a biosphere reserve

Years of conventional intensification supported by the green revolution have degraded natural resources throughout Ethiopia. Reduced soil fertility, large-scale soil erosion and persistent droughts made it impossible to grow enough food to feed the Ethiopian population. Due to pressure from environmental NGOs and local resistance to the failing strategy of conventional agriculture, the government has transformed its agricultural policy towards sustainable land management. Biosphere reserves are being established across Ethiopia to mainstream approaches that integrate conservation of natural habitat and sustainable food production. This shift was facilitated by increasing international demand for sustainably produced agricultural products, as well as the active participation of locals in the transformation process. In the southwest, the *Buna Dhuga Biosphere Reserve* has been established. This reserve emphasises not only the traditional culture of growing and drinking coffee, but also good social relationships, which are the central pillar of the newly established community-based management of the reserve.

The landscape consists of a core zone of unused natural forest, a buffer zone for low-intensity production of local coffee, wild honey, and other forest products, and an outer area with a mosaic of cropland, pastures and tree plantations. Planting of native tree species for timber, firewood and shade for coffee, is highly encouraged, and care is taken that people retain their uses and knowledge of local plants. The land is farmed using a mixture of traditional agricultural practices and modern techniques such as crop rotation, intercropping with legumes, soil and water conservation, and composting. Livestock production and communal grazing are maintained and also provide manure for fertilising the fields. People grow a wide variety of fruit and vegetables in their homegardens. Due to these sustainable practices, farmland biodiversity is recovering from earlier impacts of fertilisers and pesticides, and important ecosystem services provided by farmland, such as soil fertility, are restored.

The management of the biosphere reserve is realised through strong community participation, which also fostered the acceptance to establish a protected core zone of natural forests.

Although some forest clearing was unavoidable to accommodate the growing population in the past, the core zone now is a haven for many rare and endangered species, and also is a refuge for the wild gene pool of *Coffea arabica.* To reduce negative impacts of wild crop-raiding animals, jobs as wildlife guards have been provided through community-based arrangements, especially to local people without access to land. The wildlife guards are responsible to help scare off crop-raiding animals, provide information to farmers on how to best protect fields, and where necessary reduce the populations of the most problematic species such as baboons and bush pigs via controlled culling measures. Community-based management of the reserve supports the continuation of semi-subsistence farming and provides job opportunities for landless or poor people and minorities.

Social capital is high, and traditional collaborative agreements, such as didaro, have received renewed attention and have facilitated the transition process. Conflicts are usually solved within the community. Cultural integrity remains high and people are in good spirit. As an important part of their cultural identity, people grow and eat the majority of their own food. In addition, coffee and nature-based tourism are beginning to develop, bringing in extra money. The majority of people are now able to live in houses with metal roofs, have access to health and education, and are able to buffer their livelihoods during difficult times. Women in the region are empowered through inclusion in decision-making processes. This has led to higher acceptance of family planning and smaller family sizes, reducing population growth in the long-term. Despite limited economic growth, equality among people is high, and diversified farming combined with high social capital increases household resilience to climate change and other potential problems, such as market fluctuations or crop diseases.

Food first: intensive farming and forest protection

Due to climate change, coffee production has shifted to higher altitudes, and growing coffee has become unviable in most parts of southwestern Ethiopia due to frequent outbreaks of coffee pests and diseases. At the same time food production in the dryer parts of Ethiopia has seen a sharp decline due to increasingly frequent droughts. Given declining coffee production locally and stagnating food production in other parts of the country, the Ethiopian government declared the southwest a priority area for producing crops, fruit, vegetables, and beef. As a consequence, a rapid transition towards industrialised agriculture with high-yielding varieties and high agro-chemical input was realised. Modern agriculture almost completely replaced traditional small-scale farming and eroded local knowledge. The boost in land use intensity and efficiency

required large-scale land consolidation, including the clearing of woody vegetation and cropland expansion. Flat areas including drained wetlands are now dominated by large cereal fields. The hills and steeper slopes are used for intensified fruit and vegetable production, commercial honey bee keeping and beef fattening. The transition of the farming system was facilitated by cooperatives that provided infrastructure for inputs, marketing and financial support. Farmers had to specialise and commercialise their production, now using large amounts of pesticides, artificial fertilisers, seeds and fodder. Local crops have been replaced by fast growing new varieties that require large amounts of pesticides and fertilisers. Farming has been mechanised as much as possible, with government-owned tractors being available for hire to work the larger stretches of cropland in the flat areas. The intensification of agriculture has led to a deterioration of natural capital in farmland, decreasing soil fertility even further, and hence increasing the dependence on external inputs and new crop varieties. Freshwater sources are polluted from agrochemicals. Virtually everything harvested is sold to markets. Storage facilities and processing plants have been set up in the larger towns.

To limit further expansion of farmland, to reduce potential impacts of climate change and to satisfy international pressure for nature protection, the remaining patches of natural forest are put under strict protection. The resulting protected areas have been partially fenced to limit illegal forest use but also to reduce crop raiding from wild animals. Despite strict protection, the fragmentation and isolation of remnant forest patches has led to further decreases in forest biodiversity. Large-scale deforestation combined with intensification of agriculture has led to widespread soil erosion, which the government now tries to tackle by building dams and water channels.

Large-scale land consolidation has increased overall inequality in the region, and left many people without access to land. While farmers who managed the transition and received land are relatively well off, others remain poor. Some managed to get employment on other people's farms, but opportunities are limited because of high levels of mechanisation and a focus on efficiency. Other people have emigrated to towns in an attempt to make a living by working in one of the many food processing factories. With modernisation, individualistic behaviour has increased, and cultural identity and community cohesion have been eroded. People now mainly eat purchased and processed food, including processed meat and dairy products imported from elsewhere. Dietary diversity no longer comes from diversified cropping, but depends on what is available and affordable on the market. Due to specialisation and commercialisation, the

resilience of farmers is primarily based on financial capital. However, due to crop specialisation and the loss of many ecosystem services, farmers are not resilient to climate change, and, despite increased financial capital, some are forced into debt after unfavourable years with low harvests. Moreover, people are strongly affected by market price fluctuations to sell harvests and buy food, which further decreases their resilience. Population growth remains high, particularly among the poor. Many of the poor emigrate to towns and cities, putting additional pressure on increasingly large urban slums.

Declaration

I hereby certify that the submitted dissertation entitled ‘Institutional prospects and challenges in the governance of food security and biodiversity conservation: A case study from southwestern Ethiopia’ has been written by me without using unauthorized aids. I did not use any aids and writings other than those indicated. All passages taken from other writings either verbatim or in substance have been marked by me accordingly.

I hereby confirm that in carrying out my dissertation project I have not employed the services of a professional broker of dissertation projects, nor will I do so in the future.

This dissertation, in its present or any other version, has not yet been submitted to any other university for review. I have not taken or registered to take another doctoral examination.

Lüneburg, 14.02. 2019

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Tolera Senbeto Jiren