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Identifying governance gaps among interlinked sustainability challenges

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ABSTRACT

Sustainability issues cannot be separated from their social and biophysical context, and collaborative governance responses to interdependent sustainability issues are inherently complex. Governance gaps emerge when responsible actors fail to recognize how multiple issues and actors are interlinked. Closing governance gaps is particularly challenging for sustainability issues that intersect several sectors of society, such as livelihoods, agriculture and biodiversity conservation. This study introduces a new quantitative empirical approach that conceptualizes how governance gaps emerge at the intersection of two networks that are usually studied separately: an actor network and a network of interdependent sustainability issues. We differentiate between (1) *integrative gaps* that arise when interdependent issues are managed in separation without recognizing their interdependencies, versus (2) *collaborative gaps* that arise when actors working on common issues do not collaborate. Using data on 60 actors and 38 sustainability issues in southwest Ethiopia, we found comprehensive collaboration networks around, for example, agricultural production and land-use issues, but large collaborative gaps for forest and wildlife issues. While actors actively managed interdependencies around national high-priority issues such as coffee export and family planning, integrative gaps were common for low-profile issues such as access provision of finance, transportation, schools, food and crop markets. In general, smaller specialized actors had a stronger tendency than larger generalist actors to focus their management capacity towards the closing of governance gaps. Surprisingly, greater system complexity did not *per se* cause governance gaps, except when system interactions were cross-sectoral. Furthermore, our data suggested that integrative system management and collaboration reinforced each other. In conclusion, our network framework advances how governance gaps can be understood and prioritized in different empirical contexts. It enables a theoretically informed empirical identification of the specific sustainability issues for which targeted structural changes are most likely to facilitate improved sustainability outcomes.

1. Introduction

Managing sustainable development is a complex challenge because of the interdependency of the associated societal and environmental issues such as livelihoods, food security, biodiversity, markets and land use. The complexity increases as each of these issues is influenced by multiple governance actors with different roles, interests, beliefs and capacities. Moreover, social and environmental interconnectedness extends beyond single sectors and organizational hierarchies, and is likely to further increase with global change (Hughes et al., 2013). Such complexities bring uncertainty about the biophysical and societal dynamics of sustainability issues, and about who should be involved in tackling them (Klijn and Koppenjan, 2000). This complexity can be understood as two sets of network patterns – one network consisting of the interdependency of the multiple issues to be tackled, which is linked to another network representing the collaborations among the actors managing the issues. Given these conditions, collaborative governance arrangements combined with an integrative social-ecological system perspective is commonly put forward as a feasible means of addressing complex sustainability issues (Armitage et al., 2012; Brondizio et al., 2009; Carlsson and Berkes, 2005).

However, previous empirical research has not adequately captured the intersection of the two abovementioned networks of actor collaborations versus issue interdependencies (Bodin, Nohrstedt, 2016). Failing to address this intersection increases the risk that the actors' policies and management responses will be inefficient or have unforeseen, adverse consequences (Folke et al., 2005). Interdisciplinary research on collaborative networks shows that the interdependencies of

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different sustainability issues, which actors get involved, with whom they collaborate, and the ways in which actors are tied to the biophysical environment have profound implications on actors' abilities to address different types of societal and environmental problems (Bodin, 2017). Although the intersection between collaboration networks and networks of interdependent issues is often recognized in theory, empirical research has typically studied the two networks separately, disregarding or overly simplifying the complexity either of issue interdependency, or of the social structures among the involved actors (Pelosi et al., 2010).

One way of investigating whether collaborative arrangements are beneficial to governance effectiveness when tackling interdependent sustainability issues is to examine what constitutes an institutional fit between collaborative patterns and issue interdependency. The literature of institutional (or social-ecological) fit suggests that merely establishing a collaborative network does not guarantee successful governance. Rather, the effectiveness of collaborative governance in tackling sustainability problems largely depend on whether socio-economic structures, including the actors and their collaborative ties, are reflecting the biophysical structures (Folke et al., 2007; Galaz et al., 2008; Lebel et al., 2013; Young, 2002). Research on community-based management (Brown and Rosendo, 1998), natural resource governance (Olsson et al., 2007) and common pool resource dilemmas (Feiock and Scholz, 2009) demonstrates that governance arrangements that fail to appropriately match the structures of both the institutional and the biophysical environment often result in undesired outcomes (Epstein et al., 2015). Achieving institutional fit is challenging particularly for complex issues that span across multiple societal sectors, which is common for sustainability issues. Thus, a broad system perspective is needed to assess whether existing governance structures are beneficial to some – but not to other – sustainability issues within the same system. However, recent literature reviews (Barnes et al., 2017; Bodin, 2017) show that empirical studies on institutional fit have concentrated on a single sustainability issue or a single ecological resource type (but see Pittman and Armitage (2017) who look at the land-sea interface). Although such multi-issue perspective is required to identify specific issues with low fit, no empirical research so far has assessed how the level of institutional fit differs between different sustainability issues within the same actual system.

Cross-sector integration and collaboration are acknowledged across many different policy fields as effective means for achieving sustainable solutions (Dietz et al., 2003; Folke et al., 2005; Visseren-Hamakers, 2015). The concept of institutional fit moves beyond the general call for more collaboration and more cross-sectoral integration, which is prone to recommending managing actors to participate in ever more collaborations and to constantly take ever more system interdependencies into account – including in situations where other approaches are more suitable. A blanket recommendation of more collaborative and more integrative governance is of little value to individual actors, and it may divert resources away from addressing the most pressing governance gaps. Instead, we suggest that more targeted approaches are needed to single out those sustainability issues that suffer from low institutional fit. As actors engage with new issues and in new collaborations, such engagements are more likely to lead to desired sustainability if specifically targeting the sustainability issues with the lowest institutional fit.

With the purpose of identifying specific issues and actors with low institutional fit in our study system, we conducted a multilevel network analysis of two interlinked network levels: (1) a collaborative actor network and (2) a network of interconnected sustainability issues. Multilevel network analysis provides a framework for empirical and interdisciplinary evaluation of institutional fit, analyzing together the institutional and the biophysical dimensions of sustainability governance (Bergsten et al., 2014; Dee et al., 2017; Sayles and Baggio, 2017). Multilevel networks have also been used to understand how actors are indirectly linked through participation in multiple "policy forums" (Berardo and Lubell, 2016; Lubell et al., 2014; McAllister et al., 2014). Although such research has not explicitly focused on assessing institutional fit, it demonstrates the possibility to also cover and compare multiple sustainability issues in fit assessments. Our empirical setting is a rural area in southwest Ethiopia dominated by smallholder farming, from which we analyzed data on 60 actors, 38 issues and their interconnections (i.e. without any induced links). This system faces a series of interlinked sustainability challenges, including population growth (Teller and Hailemariam, 2011) agricultural intensification (Eshete, 2013), deforestation (Hylander et al., 2013), climate change (Moat et al., 2017), increasing foreign investment and agricultural export (Ango, 2018; Rahmato, 2011) and ambitious government policies for economic growth (Ministry of Finance and Economic Development (MOFED, 2010). The manner in which the involved actors collectively manage the interdependencies among these and other sustainability issues will have significant implications on human well-being and ecosystems.

Below, we devise two theoretical propositions about how actor-issue network configurations constitute two different components of institutional fit, which increase or decrease the chances for an effective governance of interdependent sustainability issues (Epstein et al., 2015). We are aware that actual sustainability outcomes will depend not only on institutional fit but on several other factors that we have not measured, such as power relationships among governance actors. Notwithstanding these factors, from a structural perspective, we differentiate between two components of overall institutional fit, and refer to these as *integrative fit* and *collaborative fit*. Integrative fit occurs when interdependencies among issues are managed, in contrast to when influencing actors concentrate on particular issues separately without managing their interdependencies. Collaborative fit occurs when actors who influence common issues appropriately collaborate with each other. Based on these definitions, we develop a novel positional network analysis to identify which particular issues and actors are positioned in governance structures with high versus low fit. For actors, we introduce a conceptually new aspect of institutional fit that we call *fit tendency*. By investigating fit tendency we differentiate how different actors concentrate their limited management capacity to improve the overall institutional fit. In section 2.3 we further discuss the concepts of collaborative and integrative fit within the wider literature on institutional fit. The computational details of institutional fit and fit tendency are explained in section 2.5.

We ask the following questions:

1) Which sustainability issues and actors have the lowest integrative fit – and which have the highest? That is, is interdependency among issues managed or not?
2) Which issues and actors have the lowest collaborative fit – and which have the highest? That is, are actors with common issues collaborating or not?

2. Methods

2.1. A model of actor-issue relations

Comparing issues and actors by their degree of institutional fit requires a new analytical approach. Our study is therefore partly devoted to devising a method where patterns of actor collaborations, issue interdependencies, and actor-issue engagements can be formally analyzed. Our analysis consists of on a novel combination of three existing approaches. The first is multilevel network analysis, which recognizes that dependencies exist between networks at different levels within a complex system (Dee et al., 2017; Kininmonth et al., 2015; Wang et al., 2016). This allows us to represent linkages within and between two network levels – the collaborative *actor network* and the *issue network* (Fig. 1). Second, we use a minimal-building-block approach (Berardo, 2014; Bodin and Tengö, 2012) to disentangle two different network

configurations (building blocks), each consisting of a small set of actors, issues and their interconnections. This allows us to specify theoretical propositions about the performance of the network configurations in terms of their structural capacity to support effective governance (Table 1). Third, we develop a node-positional analysis to identify the particular issues and actors with the lowest and highest fit within a system. Most previous studies have assessed institutional fit at the system level or compared multiple cases (usually using exponential random graph modelling (ERGM) Wang et al., 2016). By contrast, we focus on the individual network nodes (issues and actors) and compare their degree of institutional fit to identify the particular nodes with the lowest fit, i.e. where greater integration may be required

2.2. Empirical setting

We conducted our study in Jimma zone in Oromia regional state, approximately 350 km southwest of the national and Oromia regional capital, Addis Ababa. The Ethiopian government administration is hierarchically organized in five government levels: federal (national) level, regions, zones, districts and municipalities. Our analysis includes NGOs and government agencies from different sectors at three governance levels: Jimma zone, Setema district and Gido Beri municipality (actors are listed in Table A.2 in Supplementary material). Zonal administrations in Ethiopia are responsible for the implementation of regional- and federal-level policies, while district-level administrations are responsible for operational activities and for coordinating the municipal offices, which have very limited management resources. Recent studies show that institutional fragmentation and coordination problems are hampering governance effectiveness around sustainable development in the study area, including or issues such as food security, biodiversity conservation, agricultural market development and social-ecological resilience (Hailemariam et al., 2016; Jiren et al., 2018a, 2018b).

Jimma zone has 160 inhabitants/sq. km and experiences seasonal food insecurity (Manlosa et al. in review). Smallholder agriculture is the dominant livelihood (Ango et al., 2014). Cereals are the major food crop, and coffee production is the primary income source. Many development issues in Jimma zone such as food security are strongly interdependent with forest cover and biodiversity, including the management of forest ecosystem services and disservices (Ango et al., 2014; Jiren et al., 2018a, 2018b). Jimma zone is a regional forest priority area and part of the Eastern Afromontane Biodiversity Hotspot (Mittermeier et al., 2005), and forest cover has decreased from 54 to 40 percent in the last 40 years (Hylander et al., 2013).

Through stakeholder workshops we identified the main sustainability issues and their interdependencies, resulting in the observed *issue network* (Fig. 1). We define "interdependency" between two issues as when a change in one issue also affects another issue. Although our data included the sign or direction of interdependencies, these attributes are not utilized in our analysis because actors who manage a focal issue have reasons to recognize both causes and consequences related to a focal issue, and both positive and negative factors (for more details on the issue network see Fig. A.1 and Table A.1 in Supplementary material). Each observed sustainability issue is influenced by multiple governance actors. We include both direct and indirect ways in which actors influence issues, including operational activities, investment, monitoring, policy making and formal accountability.

Our *actor network* consists of pairwise collaborations among the actors who exert a large influence on a given sustainability issue ("influencing stakeholders" sensu Grimble and Wellard, 1997). Actors were asked to report their collaborations defined as exchange of information, expertise or resources, or joint planning and coordination of governance activities. All sustainability issues in the system were treated equally, that is, we did judge not some issues more important than others, or that some interdependencies were more critical to manage. Similarly, all actors were treated equally in the analysis, although in reality they may differ in power or capacity.

2.3. Theoretical framework

2.3.1. Integrative fit: are interdependencies among sustainability issues managed?

Sustainable development involves many different societal and biophysical components that are interdependent, and these interdependencies should ideally be recognized by integrative intervention strategies (Folke et al., 2005; Visseren-Hamakers, 2015). In this context, we define integrative misfit as when a governance actor manages a sustainability issue that is directly linked to other sustainability issues, without engaging with the linked issue (Table 1). Possible causes include bureaucratically assigned management responsibilities which do not reflect the actual interdependencies among issues, including in cases where the interdependent issue is considered to fall within the responsibility of other government sectors (sometimes referred to as silo governance). Such division may undermine an actor's capacity to understand the integrative context of its focal issues, and to foresee, prevent and detect negative spillover effects, which may result in inappropriate management responses (Armitage et al., 2009).

Conversely, an integrative fit occurs when an actor is linked to both of two interdependent issues (Table 1). With this definition, we emphasize that integrative fit does not automatically increase when an actor engages in more sustainability issues in general, but only if the issues are interdependent. A closed triangle (Table 1) means that an individual actor engages with both issues constituting a system interaction, which enables a more adequate and rapid response to changes; this is sometimes referred to as "scale matching" (Cumming et al., 2006). Also, management resources may be used more efficiently if an actor focuses on issues that are interdependent, rather than on random sets of unrelated issues. In economic terms, this implies an internalization of system-level costs and benefits (Prugh et al., 1999). Tightening the feedback loops between actions and outcomes helps the actor to learn about interdependencies and to develop holistic solutions that lead to positive synergies. Although empirical research on

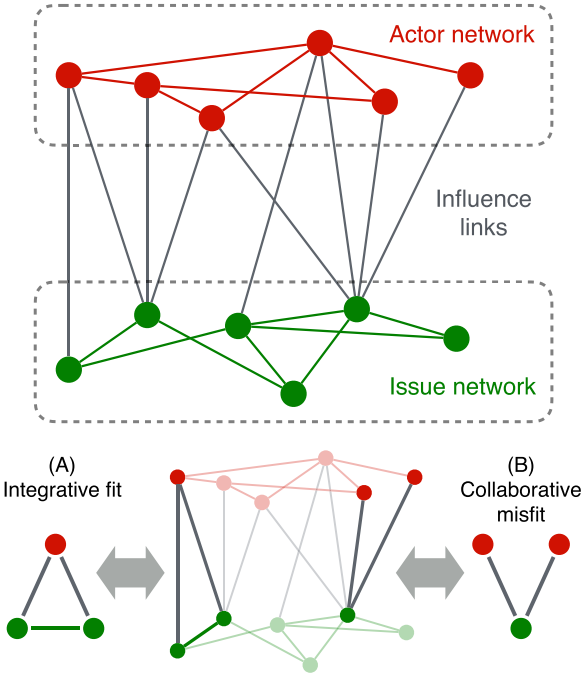

Fig. 1. Schematic representation of our two-level network model of the governance system. The model consists of nodes and links representing actors and their collaborations (the "actor network"), issues and their interdependencies (the "issue network"), and the influences that actors exert on each issue (grey links). The actor-issue configurations (insert A and B) are further explained in Table 1, and the full network with empirical data is displayed in Fig. 2.

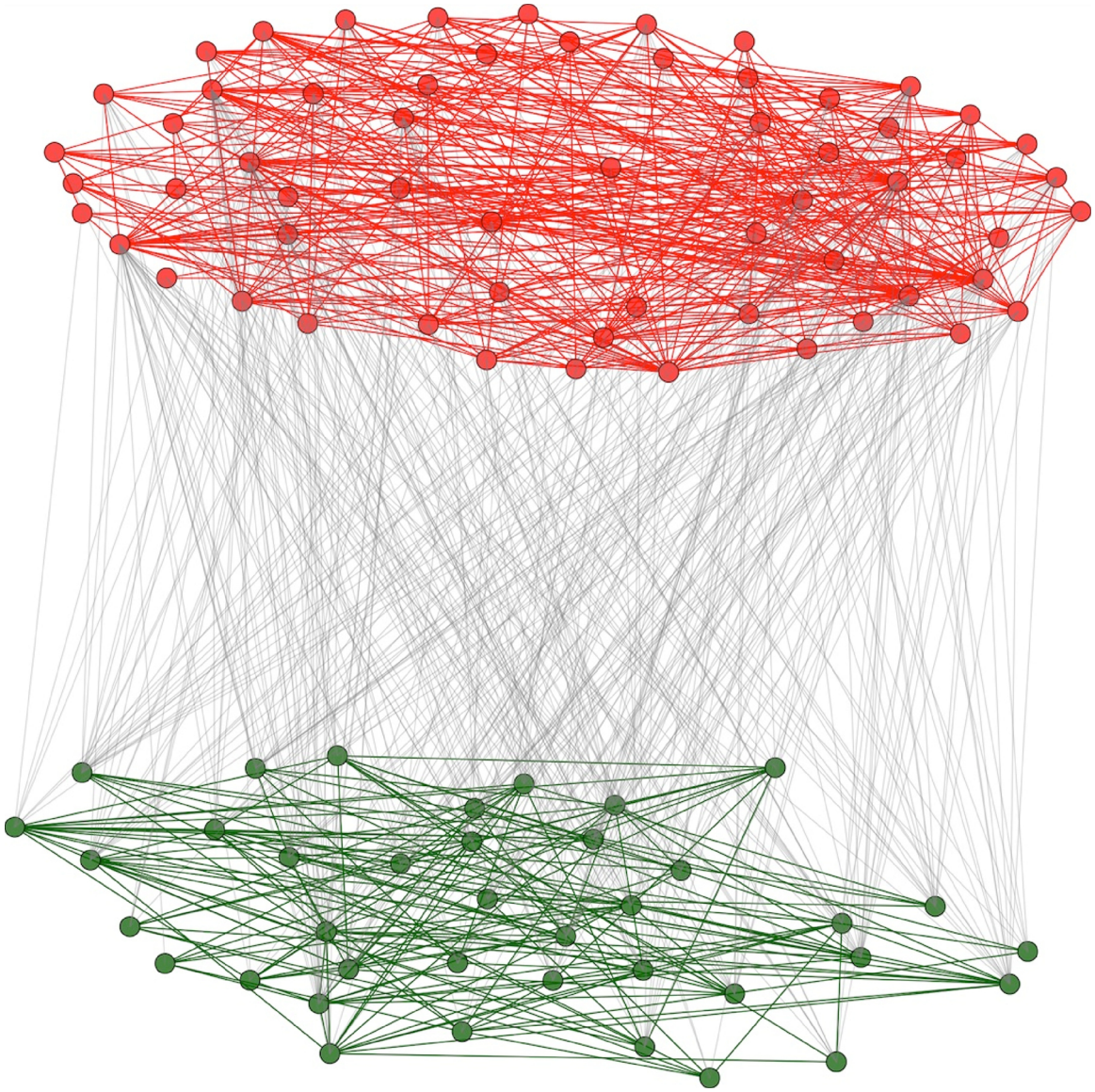

Fig 2. The full-scale two-level network encompassing all sustainability issues, actors and interconnections in the study system.

Table 1
The studied actor-issue configurations (building blocks) and their theoretical implications on institutional fit – with higher institutional fit implying better conditions for effective governance of sustainability issues. We measure and compare institutional fit on the level of single issues and single actors, rather than looking at system-level averages. Red nodes denote governance actors who may be collaborating (red link) and who have influence links (blue) to sustainability issues (green nodes) that may be interdependent (green link).

	**Integrative fit** (research question 1)
	Integrative fit (top) occurs for an issue and for an influencing actor if the actor also engages with the interdependent issue. Integrative misfit (bottom) occurs when the interdependent issue is not managed. Hypothesis: We expect that issues with many interdependencies have a lower integrative fit than issues with fewer interdependencies, because of the greater effort required by each actor to manage the many interdependencies.
	**Collaborative fit** (research question 2)
	Collaborative fit (top) occurs for an issue and for two influencing actors if actors collaborate with each other. Collaborative misfit (bottom) occurs when the actors work in isolation. Hypothesis: We expect that issues with more influencing actors have a lower collaborative fit than issues with fewer actors, because of the greater effort required by each actor to engage with the many other actors.

integrative fit is very scarce (Bodin, 2017), studies suggest that an integrative fit is more common in governance networks that perform well in terms of sustainability outcomes, for example in large-scale biodiversity conservation (Guerrero et al., 2015) and small-scale fisheries (Bodin et al., 2014).

2.3.2. Collaborative fit: are actors with common issues collaborating?

A collaborative misfit occurs when two actors working on a common issue are not collaborating with each other, but instead act independently and without adjusting to each other's management activities (Table 1). This may lead to conflict and unnecessary duplication of work, to miscommunication and counteractive management responses, and to overexploitation of natural resources (Ostrom, 1990). The risk of a low collaborative fit is inherent to sustainability issues that extend beyond organizational boundaries, or that more generally involve many actors with different beliefs, interests and capacities (Bergsten et al., 2014; Lebel et al., 2005).

Collaborative fit improves when two actors with a common issue establish a collaboration, allowing each actor to adjust their actions in response to management decisions made by other actors (Table 1). As with our definition of integrative fit, collaborative fit does not automatically increase when an actor engages in more collaborations in general, but only through collaborations with actors who influence the same issue. Collaborative fit supports negotiation and agenda setting, planning and coordination of joint activities, division of labor, and promotes social acceptance of implemented solutions (Bodin and Crona, 2009). Collaboration around common tasks also enhances the accessible pool of knowledge and experience, which is often crucial in solving complex problems (Prell and Lo, 2016). We assume that collaboration around common issues is usually good, but we recognize that there are exceptions – such as competition between two actors, when collaboration is not helping actors to pursue their agendas. Collaborative fit has been shown to improve performance in common-pool resource governance (Ostrom, 1990), and in collective response to natural disasters (Bodin, Nohrstedt, 2016).

2.4. Data collection

Data for the issue network were collected in 2015 through workshops with 30 stakeholders representing, among others, the local farmer community, cooperatives, religious leaders, women's organizations and government agencies responsible for agriculture, natural resources, finance and social affairs at municipal, district and zonal levels (stakeholders are listed in Table A.3 in Supplementary material). The workshop participants were asked to state the most important issues in sustainable development and their interdependencies, starting with the themes of food security and biodiversity conservation and then covering themes relating to the different interests of the workshop participants. The broad representation of stakeholders enabled us to cover many sustainability issues spanning several government sectors and diverse stakeholder interests. Five experts on sustainability in the study area were consulted to synthesize the data from the individual workshops into an issue network representative for the study area, focusing on the issues and interdependencies that received the most attention in the workshops.

Through in-depth interviews in 2015-16 we surveyed the governance actors, their collaborations and their influence on the issues. The actor interviews did not generate any additional issues for the issue network, which was based only on the previously conducted workshop discussions described above (in which some of the interviewed actors had participated). The analyzed actors were identified through snowballing as described in Jiren et al., (2018a, 2018b) and included government, non-governmental and community-based organizations in the Jimma zone (listed in Table A.2 in Supplementary material). Every node in the actor network layer represented an agency or an organization, for which we interviewed at least one individual in a key position, such as planners, experts and heads of organizations (Jiren et al., 2018a, 2018b). The actors were asked to state which issues they influenced, and their collaborations with other actors concerning sustainable development. The full two-level network encompassed in total 60 actors with 355 reciprocal collaboration links and 382 influence links to 38 issues with 155 interdependency links (Fig. 2). Some nodes (issues and actors) were excluded from our results section, either because we lacked collaboration data from the influencing actors, or because the nodes had too few observed occurrences in the analyzed actor-issue configurations in Table 1 (see Supplementary material for methodological details).

2.5. Data analysis

To compare the sustainability issues by their degree of collaborative and integrative fit, we designed a node-positional analysis based on the occurrences of each issue and each actor in the selected actor-issue network configurations (fit versus misfit, Table 1). For integrative fit, we measured fit as the mean percentage of a focal issue's interdependencies that were directly managed by the influencing actors. The integrative fit measure thus equaled the proportion of integrative fit triangles that were closed (Table 1). We measured collaborative fit for a focal issue as the percentage of present collaboration links among all actors influencing the focal issue. Hence, the collaborative fit measure equaled the proportion of collaborative fit triangles that were closed (Table 1). Further details on how the fit measures were computed are given in the supplementary material.

Our research questions aimed at identifying the issues and actors with high versus low fit, relative to the other issues within the study system. We therefore set a threshold for low and high fit at ± 1 standard deviation. Consequently, we identified a low fit if the (integrative or collaborative) fit value was lower than 1 standard deviation below the mean, and a high fit if higher than 1 standard deviation above the mean. These cases of high and low fit are the primary focus of the results section. The remaining cases, which fell within ± 1 standard deviation, were used only to analyze trends and correlations corresponding to general system properties. We used linear regressions to test whether an issue's institutional fit could be explained by its number of managing actors and interdependencies, corresponding to our two hypotheses that greater complexity required actors to engage in more collaboration and management activities to achieve a certain level of fit (Table 1). Pearson's correlations were used to test whether integrative fit and collaborative fit cooccurred. We calculated (exact) p-values of regression and correlation coefficients using the permutation procedures in the R packages "lmPerm" and "jmuOutlier", respectively. Such permutation tests are suitable when it cannot be assumed that data come from normal distributions (Wheeler, 2010).

This study also introduces a new perspective of institutional fit that we label "fit tendency" and that we applied to further investigate an actor's tendency to concentrate their management and collaboration capacities around its core issues. Fit tendency controls for the fact that different actors have very different capacities to engage in many collaborations and to manage many interdependent issues. Whereas an actor can improve their institutional fit measure simply by broader engagement in a higher number of issues and collaborations, such behavior will reduce the actor's fit tendency. We calculated an actor's integrative tendency as the regression residuals in *Integrative fit ~ total number of issues that the actor influences* (regression diagrams in Fig. A.3 in Supplementary material; network diagrams in Fig. A.4). Consequently, the integrative tendency measured the extent to which an actor used its limited management capacity to manage interdependent issues, in contrast to simply getting involved in more issues. Analogously, the collaborative tendency equaled the residuals in the regression *Collaborative fit ~ total number of collaborations (partners)*. The collaborative tendency thus measured the extent to which an actor used a limited collaboration capacity to collaborate specifically with partners having common issues, rather than simply getting involved in more collaborations.

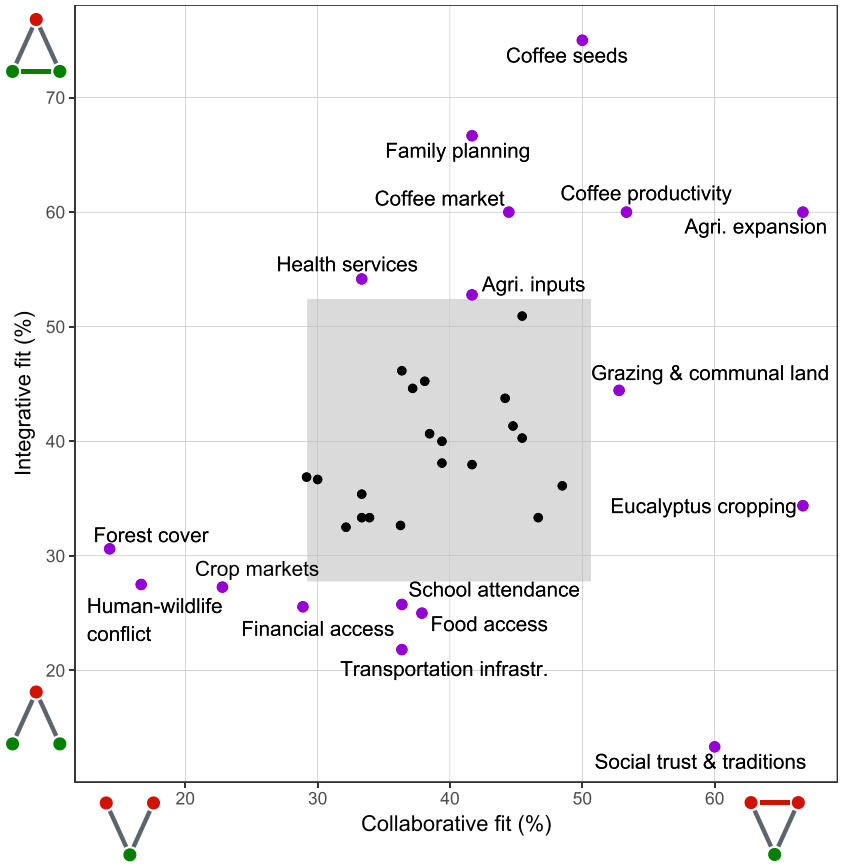

Fig 3. Institutional fit of sustainability issues. Integrative fit for an issue is measured as the mean percentage of its interdependent issues that are managed by its influencing actors, equaling the proportion of closed network triangles depicted on the y-axis. Collaborative fit is the percentage of present collaboration links among all actors influencing the focal issue, i.e. the proportion of closed triangles on the x-axis. The labeled purple data points mark issues with high and/or low fit, i.e. falling outside the shaded area that delineates ± 1 standard deviation; other issues are not labeled (black points).

3. Results

There was a positive significant correlation between the integrative and the collaborative fit of a sustainability issue ($r = 0.35$; $p = 0.03$). The mean integrative fit of the issues was 40.1 percent, with high fit being above 52.5 percent and low fit being below 27.7 percent (see section 2.5 for definition of high versus low fit). The mean collaborative fit was 39.9 percent, with high fit being above 50.7 and low fit being below 29.1 percent.

3.1. Issues with high institutional fit

Agricultural expansion and *Coffee productivity* were the issues that had both high integrative and high collaborative fit (Fig. 3). Focusing on integrative fit only, a high fit occurred also for *Coffee seeds*, *Coffee market*, *Agricultural inputs*, *Family planning* and *Health services* (Fig. 3). Collaborative fit was high for several major land-use issues, namely *Agricultural expansion, Eucalyptus cropping*, *Coffee productivity* and *Grazing & communal land* (Fig. 3). Collaborative fit was high also for *Social trust & traditions*, which showed very low integrative fit – unlike the land-use issues above. The presence of governance structures corresponding to institutional fit are illustrated in Figs. 4 and 5. For example, the actors managing *Family planning* were also involved in the interdependent issues (high integrative fit in Fig. 4). There were many collaboration links among the actors managing *Agricultural expansion* (high collaborative fit; Fig. 5).

3.2. Issues with low institutional fit

All issues with low integrative fit also had a below-average collaborative fit, and vice versa, with the exception *Social trust & traditions* (Figs. 3 and 4). This means that lacking structures for integrative system governance coincided with lacking collaborative structures, especially for *Human-wildlife conflict*, *Crop markets* and *Financial access* which were low on both integrative and collaborative fit. In addition, integrative fit was low also for several other issues concerning the access to public services, namely *Transportation infrastructure*, *Food access* and *School attendance*. *Forest cover* had the lowest collaborative fit overall (Fig. 5).

3.3. Complex versus cross-sectoral issues

Surprisingly, we did not find evidence for the hypothesis that an issue with many interdependencies would suffer to a greater extent from its actors not managing this complex system interplay. This means that actors in general were engaged in more interdependencies and in more collaborations around complex issues with many links. Specifically, an issue's integrative fit did not decrease with a greater total number of interdependencies (regression results: $R^2 = 0.04$ *and* $p = 0.11$). For example, *Coffee productivity* with 10 interdependent issues had an equally high level of integrative fit (60.0%) as *Agricultural expansion* with 5 interdependencies (Table 2), despite a much greater effort being required to manage so many interdependencies. Similarly, there was no support for the hypothesis that collaborative fit would be hampered by greater social complexity in terms of more influencing actors. Collaborative fit did not decrease as more actors were involved ($R^2 = 0.03$ *and* $p = 0.16$); nonetheless, the number of actors was below average for all the issues with high collaborative fit (Table 2).

We found, however, that cross-sectoral issues had a lower integrative fit in general, whereas single-sector issues had a higher integrative fit. All issues with high integrative fit were single-sector issues in the sense that the government administration had assigned clear management responsibilities for these issues to certain actors within certain government sectors. Most high-fit issues were also highly prioritized by federal government development policies. One example is the coffee sector including *Coffee seed* distribution, *Coffee productivity* and *Coffee market* (Fig. 2). By contrast, most of the issues with low

integrative fit were cross-sectoral issues displaying a broader system interplay with issues in other sectors, and also considered as supportive factors for the issues prioritized higher by the government, such as *Social trust & traditions, Financial access, Food access* and *Human-wildlife conflict*. A simple yet indicative example is the difference between the narrower *Coffee markets* (high integrative fit) with the broader *Crop markets* (low fit).

3.4. High institutional fit for resource-strong actors

There was a positive moderate general correlation between an actor's integrative and collaborative fit ($r = 0.32$; $p = 0.02$; see Table A.2 in Supplementary material). The level of fit for individual actors was largely a result of the actor's total number of issue and partners ($R^2 = 0.72$ for *integrative fit ~ #issues*, and $R^2 = 0.62$ for *collaborative fit ~ #partners*). This correlation was simply due to probabilities; as an actor linked to more and more of the issues and actors in the study system, the likelihood decreased to miss the interdependencies and partners of any given issue. As a result, we found the highest levels of fit for several large generalist government actors (with many links). For example, integrative fit was highest for the *Agricultural bureaus* on all three government levels (BOAJZ, BOASE, DaG) followed by the *Cooperative development office* (COPJZ), which are all actors that primarily focus on increasing agricultural productivity (fit values and full actor names are provided in Table A.2 in Supplementary material). Collaborative fit was highest for the *General administration* and *Agricultural bureaus* (ADMJZ, ADMSE, LeG; BOAJZ, BOASE) and the federal *Jimma university* (JUJZ). These actors have broad responsibilities and great authority – matched by large budgets – to collaborate with relevant actors and to manage interdependencies across multiple government sectors. Since actors have different capacities to be involved in many collaborations and in many issues, in the following section we focus on their fit tendency.

3.5. Stronger fit tendency for smaller specialist actors

Three actors displayed a strong integrative tendency on all three governance levels (Fig. 6); namely the *Public health offices* (HEALJZ, HEALSE, HeG), the *Forest and wildlife offices* (OFWESE, OFWEJZ, network diagram shown in Fig A.4 in Supplementary material), and the *Education offices* (EDUJZ, EdG). A strong integrative tendency reflects that each of these smaller, single-sector specialist actors focused a single core of related issues, avoiding involvement in other issues. By contrast, we found a weak integrative tendency for actors working with financial access including large investments, microcredits and economic activities in different business sectors (MEISE, MEIJZ, INVSSE, FIEDSE, OCSAJZ). This tendency means that actors focusing on financial access were connected to many different issues. Furthermore, none of the resource-strong generalist authorities displayed strong fit tendencies. The actors' integrative and collaborative tendencies showed no correlation ($r = 0.15$; $p = 0.30$). This implies, for instance, that among the actors who managed interdependent issues rather than unrelated issues (strong integrative tendency), some selected partners working on the same issues (strong collaborative tendency; e.g, HEALSE) whereas others selected partners working on other issues (weak collaborative tendency; e.g, EDUJZ).

4. Discussion

Our novel analytical approach provides a way to investigate how governance structures conducive to institutional fit are distributed unevenly among the many societal issues interconnected actors in a real-world system. By contrast, previous research has studied institutional fit at the aggregate system level, in systems defined by one single environmental issue or one type of ecological resource. Acknowledging that sustainable development consists of many interdependent issues, we broadened the scope to more precisely identify specific and multiple governance gaps existing within the same system. These gaps, we argue, call for a closer investigation on how the low level of institutional fit is hampering the governance actors from effectively achieving intended sustainability outcomes (Fig. 7). Such an investigation must take into account that structural fit is only one of several factors that determine outcomes. Other factors were considered outside the scope of our analysis, and our discussion therefore focuses on structural governance gaps, including plausible causes and remedies.

4.1. Bridging gaps of low fit

Sustainability issues and actors with low institutional fit pose a risk that interventions will not effectively lead to desired outcomes. In the case of low integrative fit, governance effectiveness is hampered because important system interdependencies remain unmanaged. A low integrative fit also means that interventions targeted at a certain issue are more likely to have side effects on interdependent issues that the actors had ignored, not foreseen, or considered as externalities. For example, the lowest integrative fit occurred for *Social trust & traditions*. None of its actors managed the interdependencies with *Khat cultivation*, *Coffee investors*, *Financial access*, and *Women's participation* (isolated nodes in Fig. 4), which according to our workshop participants were all critical factors that influenced *Social trust & traditions* in the study area.

Table 2
All analyzed sustainability issues ordered by their integrative fit. For definitions of the issues, see Table A.1 in Supplementary material.

Issue	Actors	Interactions	Integrative fit (%)	Collaborative fit (%)
Coffee seeds	8	3	75.0	50.0
Family planning	9	4	66.7	41.7
Coffee market	10	9	60.0	44.4
Coffee productivity	6	10	60.0	53.3
Agri. expansion	7	5	60.0	66.7
Health services	12	4	54.2	33.3
Agri. inputs	9	12	52.8	41.7
Crop diversity	12	9	50.9	45.5
Agri. intensification	11	13	46.2	36.4
Forestry investment	7	6	45.2	38.1
Dietary diversity	13	5	44.6	37.2
Grazing & communal land	9	5	44.4	52.8
Food self-supply	16	8	43.8	44.2
Farm modernization	15	10	41.3	44.8
Crop commercialization	13	14	40.7	38.5
Cooperative functioning	12	6	40.3	45.5
Livestock production	12	10	40.0	39.4
Honey production	12	7	38.1	39.4
Farmland biodiversity	9	12	38.0	41.7
Farmer specialization	16	10	36.9	29.2
Labor market	5	6	36.7	30.0
Land tenure	12	12	36.1	48.5
Soil fertility	13	10	35.4	33.3
Eucalyptus cropping	4	8	34.4	66.7
Coffee investors	3	6	33.3	33.3
Women's participation	19	6	33.3	33.9
Security enforcement	6	3	33.3	46.7
Participatory NRM	14	7	32.7	36.3
Forest biodiversity	8	10	32.5	32.1
Forest cover	7	14	30.6	14.3
Human-wildlife conflict	4	10	27.5	16.7
Crop markets	19	11	27.3	22.8
School attendance	11	6	25.8	36.4
Financial access	10	9	25.6	28.9
Food access	12	5	25.0	37.9
Transportation infrastr.	11	10	21.8	36.4
Social trust & traditions	5	9	13.3	60.0
Mean	10.3	8.2	40.1	39.9
Standard deviation	4.0	3.0	13.1	11.4
High fit above			52.5	50.7
Low fit below			27.7	29.1

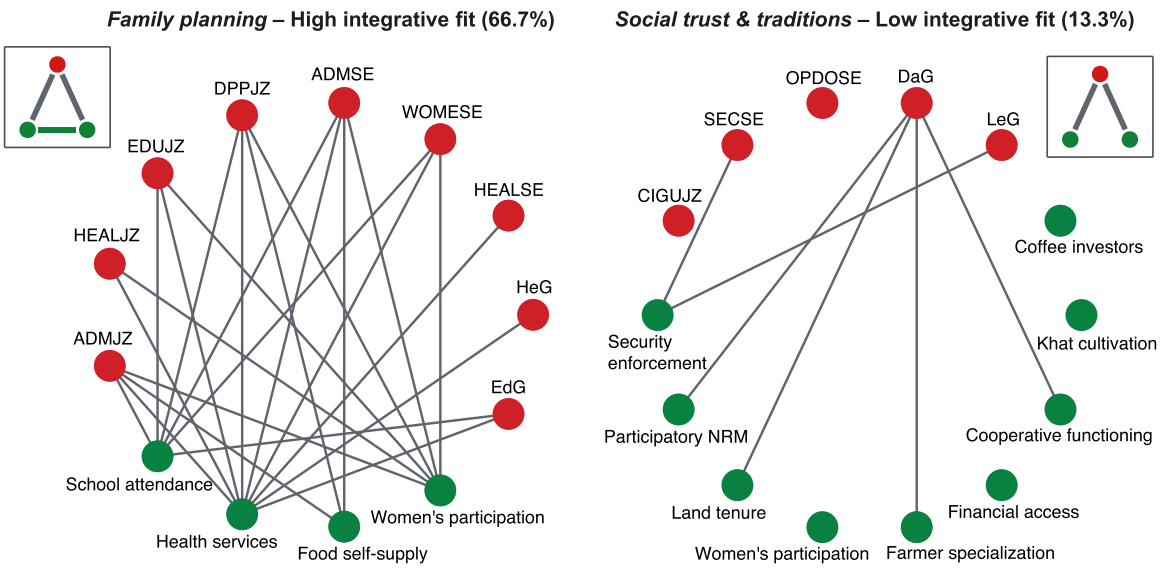

Fig. 4. Two issues with low versus high integrative fit. All displayed nodes are linked to the focal issue (focal node not shown), i.e. each figure show all the influencing actors (red nodes) and all the interdependent issues (green nodes) of the focal issue. A blue link means that an actor is also influencing (managing) an interdependency of the focal issue. Hence, each present blue link from an actor to an interdependency represents a closed triangle (insert B. Each absent blue link represents an open triangle (insert A). Actor collaboration links are not displayed here, since these links are not part of the actor-issue configuration corresponding to integrative fit (see Table 1). Left: *Family planning* had high integrative fit because the presence of influence links from the influencing actors to the issues interdependent on *Family planning*. Right: *Social trust & traditions* had low integrative fit because the absence of influence links from the actors leave the interdependent issues unmanaged by all or most actors.

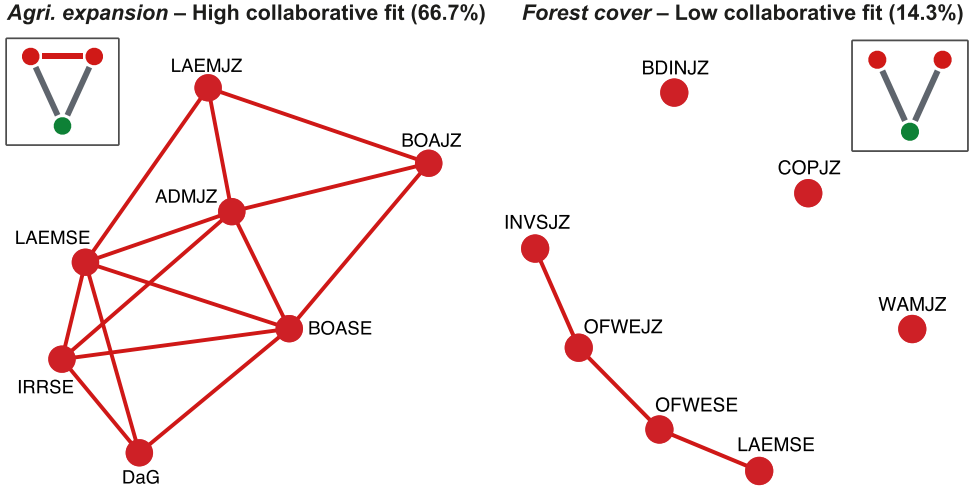

Fig. 5. Example issues with high versus low collaborative fit. Each red link represents a collaboration between the actors (red nodes), who have influence links to the focal issue (focal node not shown). Left: *Agricultural expansion* had high collaborative fit because the influencing actors had many collaborations with each other. Right: *Forest cover* conservation had low collaborative fit because the actors had very few collaborations with each other.

For example, many farmers have recently shifted from growing food crops to growing khat (*Catha edulis*) – a profitable cash crop used as a stimulant. Local farmers consider khat cultivation to undermine traditional social institutions such as labor sharing among farm neighbors and increase suspicion for theft (Gebrehiwot et al., 2016). Furthermore, *Social trust & traditions* is negatively affected by the spread of *Coffee investments* in large-scale plantations, but positively affected by a more regulated *Financial access* and by increasing *Women's participation* in the society.

A low *collaborative* fit, on the other hand, implies according to previous research a risk that the actors make uncoordinated interventions that fail because of lack of collaboration ties needed for actors to negotiate goals and agendas, and for sharing resources and information (Ostrom, 1990) – which in turn increases the risk for miscommunication, conflict and unnecessary duplication of work. In our case study, *Forest cover* and the closely related *Human-wildlife conflict* had the lowest collaborative fit, followed by *Crop markets* and *Financial access*. It is likely that the lack of collaboration and coordination around *Forest cover* and *Human-wildlife conflict* is partly a result of silo management and conflicting interests among the influencing actors (see Fig. 4 and Jiren et al., 2018a, 2018b). For example, whereas the *Forest and wildlife enterprise agency* dominantly promote forest and wildlife conservation, other influencing actors pursue different, potentially conflicting goals such as exploitation of forest natural resources and the management of forest ecosystem services and disservices to promote local human wellbeing and agricultural production. Nonetheless, coordinating the main actors who influence the issues *Forest cover* and *Human-wildlife conflict* is an important measure towards reaching an ecologically and socially viable use of forests in our study area. This example demonstrates how our analysis guides individual actors where to bridge governance gaps, by identifying the actors that are the most valuable to reach out to and make common agreements with, depending on their respective interests and capacities in the common issue.

The above issues of low fit contrast with several cases of high fit

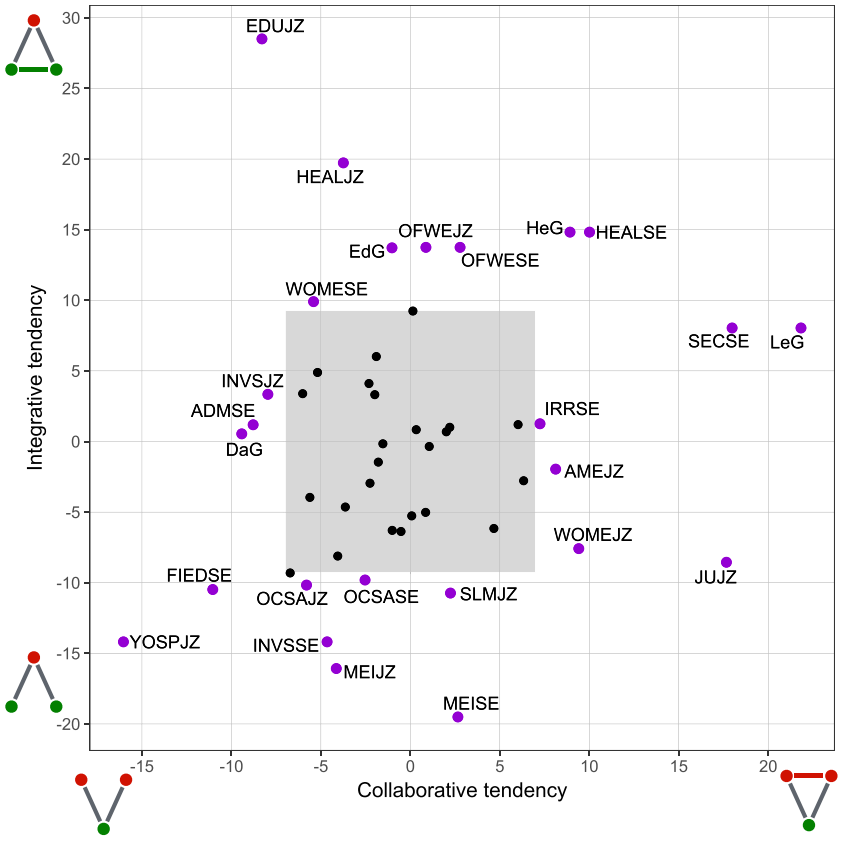

Fig. 6. Tendency of actors to improve institutional fit when selecting issues and partners. A strong integrative tendency meant that an actor tended to select interdependent issues, rather than selecting issues randomly. A high collaborative tendency meant that an actor collaborated specifically with partners with common issues, rather than selecting partners randomly. The labeled purple data points mark actors with high and/or low fit tendency, i.e. falling outside the shaded area that delineates ± 1 standard deviation; other actors are not labeled (black points). Full actor names are provided in Table A.2 in Supplementary material.

identified by our analysis, which could present a learning example for low-fit issues. We found high fit for a several issues relating to agricultural production, with particularly high integrative fit for several issues of coffee and agricultural production, and high collaborative fit especially for several land-use issues (Fig. 3). The existing institutional fit for each of these issues can be used as a leverage point to develop integrative solutions in a collective manner. Because each actor engages with a large proportion of the interdependent issues and with the involved “co-managers”, there are governance structures in place for negotiation and agenda setting across broad coalitions, providing a possibility for social learning and for bringing together diverse knowledge about the focal issue and its system interplay.

We suggest that policy makers investigate more closely the issues that had the lowest and the highest levels of fit, which can be a step towards a more efficient use of management resources across the system (illustrated in Fig. 7). Such investigation could suggest, hypothetically, that resources used for management and collaboration are shifted from particular issues with "overcollaboration or “overmanagement” (more likely issues with very high institutional fit, also see section 4.3), to issues where the lack of adequate management and collaboration is found to hamper the achievement of sustainable outcomes (more likely issues with very low fit). Integrative governance gaps, for example, can be bridged if the influencing actors recognize and adapt their management to the system interactions. When actors engage with interdependent issues and close open integrative-misfit triangles, they tighten the feedback loops between actions and system outcomes and internalize system costs and benefits, which supports them to develop integrative solutions. The actors who most contributed to institutional fit at system level were the generalist government authorities with large capacities and broad responsibilities (Section 3.4). However, these actors did not display a strong fit *tendency* (Section 3.5 and Fig. 6), indicating an inefficient use of management capacity when addressing structural governance gaps. Conversely, interdependency management was most efficient for smaller, local actors who specialized on either public health, education or forest and wildlife management (Section 3.5). We developed the concept of fit tendency to in this way account for whether actors tend to concentrate their management capacity towards a core nexus of similar issues, and towards collaboration partners with common issues, in contrast to selecting unrelated actors and issues. More specifically, actors with a strong collaborative tendency were “collaboratively specialized” in the sense that they avoided collaborating with partners who did not work on the same issues. Actors with a strong integrative tendency were “thematically specialized” in the sense that they avoided engaging with issues outside their core focus.

There are particularly good conditions to collectively achieve synergies and integrative solutions when several related issues all have high fit, which occurred for most land-use issues in our study system: *Agricultural expansion, Grazing & communal land, Coffee productivity* and *Eucalyptus cropping* (Fig. 3). The existing collaboration networks around these issues could be leveraged in order to jointly and proactively discuss potential land use conflicts. However, a successful collective and integrative approach to the land-scarcity issues in our study area would need to integrate also the actors working on forest issues such as *Forest cover* and *Human-wildlife conflict*, which had the lowest collaboration levels of all issues (Figs. 3 and 5). This result suggests that establishing coordination among forest actors would be beneficial also more broadly when solving cross-sectoral land scarcity problems.

4.2. Integrative and collaborative governance are closely related

Integrative and collaborative fit were significantly correlated for the sustainability issues (Pearson’s $r = 0.35$; $p = 0.03$). If we take the perspective of an influencing actor, a plausible cause for why the two aspects of fit correlate is that they create a reinforcing feedback in which collaboration on common issues creates leverage for more integrative management on those issues, and vice versa, thus amplifying each other. First, an actor is likely to recognize interdependencies through

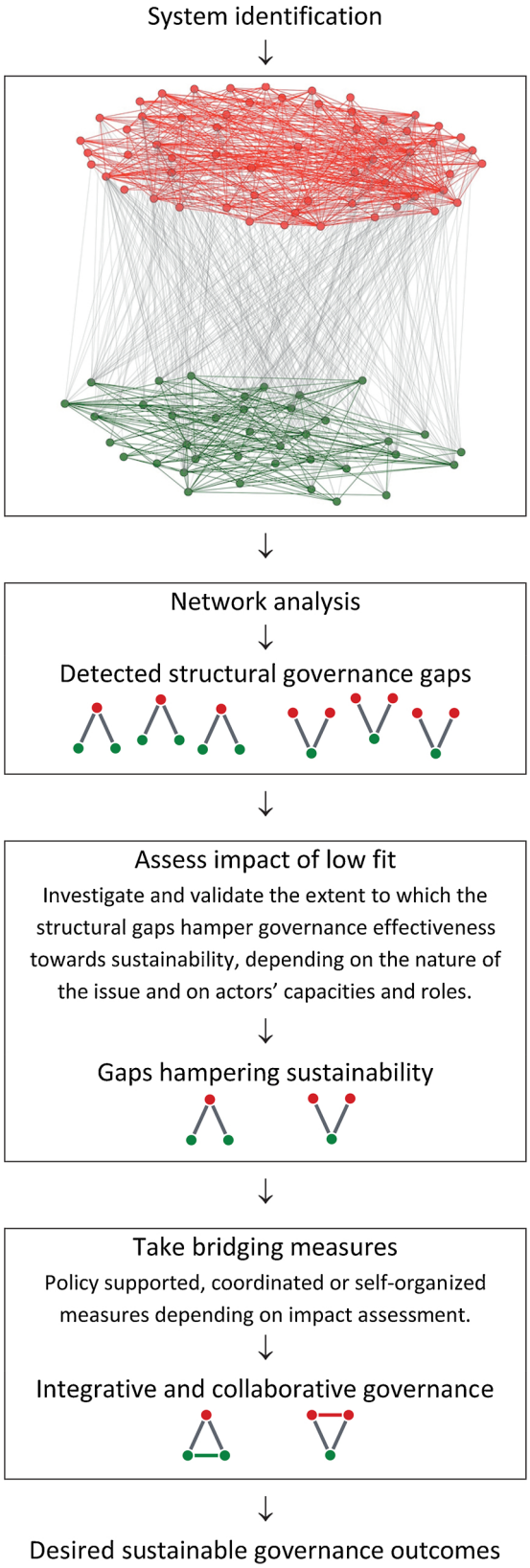

Fig. 7. Stylized process of how the approach pre- sented in this paper can help improve sustainability.

collaboration and social learning from others who have experience from managing common issues. Second, a managing actor who tends to integrate interdependencies is more likely to acknowledge the roles that other actors have in influencing a particular issue. This recognition of the influence of other actors is a necessary (but not always sufficient) reason for approaching these actors and forging collaboration ties. The general correlation of integration and collaboration demonstrates that the actors seemed to practice the above mechanisms that reinforce the fit, similar to what is described in the literature on social learning and adaptive integrative management (Berkes, 2009). However, this feedback loop did not seem to be active for the issues *Social trust & tradition*, which had low integrative fit despite a high collaborative fit (Figs. 3 and 4).

4.3. Balancing fit by combining self-organization with central coordination

Increasing an already high level of fit does not necessarily further improve the conditions for governance effectiveness. For example, a very high level of integrative fit may indicate that more actors than relevant are "overmanaging" the same interdependency of a focal issue, for instance in a situation when having just one or a few responsible actors would be sufficient. Our analysis suggests that balancing the level of fit needs to be prioritized at the sector scale or system scale, in order to strategically avoid redundant and costly collaborations and management interventions, and to promote relevant ones. Situations in which interdependency management and/or actor collaboration is either excessive or deficient may be avoided more effectively if there is a designated central coordinator role that complements self-organization processes among (semi-)autonomous actors (Leventon et al., 2017). Coordinator roles can be incorporated into our analytical approach by extending the actor-issue configurations with an additional coordinator actor who without being directly linked to the focal issue channels information exchange and delegates tasks among managing actors, thereby ensuring that interdependencies are adequately managed (cf. Table 1 and Kininmonth et al., 2015. This coordination task may be performed by a public agency with mandate and capacity to coordinate other actors in a certain sector (a "network manager"; Klijn and Koppenjan, 2000). The coordination role may achieve institutional fit by allocating collaboration and management resources to different managers that are crucial for management certain interdependencies. An example from our case study is the collaboration network around *Agricultural expansion* in which the *General zonal administration* (ADMJZ) occupied a central position (Fig. 5). In theory, if ADMJZ takes responsibility for coordinating other actors by linking them indirectly, the total number or collaborations and associated transaction costs may be reduced while still maintaining an effective coordination around *Agricultural expansion*. It is important in this context to note that actors with central coordination responsibilities need to fulfil high standards of legitimacy and accountability that match their powerful network position. Finding an appropriate balance between self-organization and centralization also depends on the nature of the particular issue. Studies show that centralized coordination is effective especially for issues with high levels of consensus, whereas polycentricity and self-organization render more innovative and viable solutions when problems are ill-defined and knowledge is uncertain (Hisschemöller and Hoppe, 1996; Sandström and Carlsson, 2008).

4.4. Cross-sectoral issues and access provision need more integrative governance

Our analysis showed that institutional fit was not generally lower for complex issues with many interdependencies and many influencing actors. This result indicates that complex network structures do not, *per se*, prevent actors to forge the additional collaborative and managerial links required to achieve integrative and collaborative fit around complex issues. However, while some issues had interdependencies mostly within a single government sector, other issues displayed interdependencies spanning multiple sectors, thus requiring that actors with a strong integrative fit tendency engaged more broadly with issues

outside their own primary sector. In fact, we found that integrative fit was lower for cross-sectoral issues and higher for single-sector issues, of which most also had high priority in federal development policies and whose management goals were consensually well-defined (cf. MoFED, 2015; Jiren et al., 2018a, 2018b). For example, integrative fit was high for issues concerning agricultural production and in particular concerning coffee production, and also for *Family planning* and *Health services* (Figs. 3 and 4). Federal development plans and ongoing research indicate that the issues with high integrative fit aligned well with how government departments are organized around high-priority goals such as limiting the population growth and maximizing the productivity of export crops and coffee (Jiren et al., 2018a, 2018b; MoFED, 2015). Conversely, many of the issues with low integrative fit had in common that they were cross-sectoral, had low priority in federal policy, and concerned the provision of access to public services and resources; such as *Financial access*, *Crop markets*, *Food access, School attendance, Transportation infrastructure and Human-wildlife conflict* (Fig. 3; MoFED, 2015, 2003). Note that a high integrative fit as defined in this study may not be desirable if the cross-sectoral interdependent issues lie beyond the scope of influencing actor. For instance, *Financial access* is mostly provided by banks and similar actors who have few reasons to also manage the related activities that they finance (e.g., forestry or farming). This logic is supported by the result that most actors working with providing financial access displayed a weak integrative tendency (section 3.5).

5. Conclusion

Sustainability issues cannot be separated from their social and biophysical context, and the collective governance of interdependent sustainability issues is inherently complex. Governance gaps emerge when responsible actors fail to recognize how multiple issues and actors are interlinked. Our study concentrated on two types of governance gaps, namely (1) integrative gaps arising when complex issues are managed in separation meaning that interdependencies among issues are not managed, and (2) collaborative gaps arising when actors working on common issues are not collaborating with each other. Our novel analytical framework which we applied to sustainable development in Ethiopia, advances how structural governance gaps around complex issues are identified and diagnosed, moving beyond the simplified but common assertion that more collaboration and more cross-sector integration is desirable for all sustainability issues. Introducing the concept of institutional fit *tendency*, we contrasted the governance actors by their tendency to efficiently utilize a limited management capacity when addressing governance gaps. Whereas previous research has studied governance gaps around a single sustainability issue, our framework explicitly pointed out that beneficial governance structures are absent around some issues, but in place around other issues. For example, we found a collaborative gap around forest and wildlife conservation but dense collaboration around issues relating to agricultural production, despite these issues being highly interdependent. We found an integrative gap with unmanaged issue interactions around social trust and traditional culture, whereas the management of family planning was much more systemic and integrative. Although such governance gaps require closer investigation, our approach is a first step towards prioritizing where governance changes are most likely to improve future sustainability outcomes, based on the actor-issue configurations around each sustainability issue (Fig. 7). The actor-issue configurations in our framework (Table 1) facilitated mechanistic and detailed insights about existing governance structures, and we thereby contributed to bridging the gap between the abundant but largely theoretical claims in the policy literature about how different governance arrangements are able to address sustainability issues, and the empirical foundations on which many of these claims ultimately rest. Our results suggest more generally that self-organized collaborative arrangements would likely benefit from some central coordination to not only bridge gaps but also to avoid "overcollaboration" and "overmanagement" around certain issues. We hope that our research will encourage further empirical studies of how complex societal challenges can be tackled more effectively in different governance settings.

Declarations of interest

None.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.envsci.2018.10.007.

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