RESEARCH ARTICLE

A multi-level assessment of changes in stakeholder constellations, interest and influence on ecosystem services under different landscape scenarios in southwestern Ethiopia

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Abstract

Growing global interconnections facilitate inter-regional flows of ecosystem services (ES). Several studies have focused on the opportunities, risks, and governance of telecoupled ES. However, considerable theoretical, methodological, and empirical gaps exist regarding how future demand for ES will shape trajectories of land use change, the bundles of ecosystem services and related livelihoods provided by future landscapes. This paper explores how multi-level stakeholder constellations, interests, and influence on ES change with a shift in the landscape from the current landscape to alternative future scenario landscapes. We integrated three methodological concepts: space-for-time substitution, scenario planning, and multi-level stakeholder interest and influence mapping. We focused on a smallholder farming landscape in southwestern Ethiopia that is characterized by, and sensitive to, rapid social-ecological change. We build on previous research that developed four plausible scenarios of landscape change for the landscape over the coming 20 years: the "Cash crops", "Coffee investors", "Biosphere reserve", and "Food first" scenarios. We treated the current (focal) landscape as the baseline. Based on space-for-time substitution, we selected four existing landscapes nearby as proxies representing the types of changes described in the four scenarios. In both focal and scenario landscapes, we then identified stakeholders and interviewed them about their interest and influence related to ES (n = 122). Stakeholder constellations, interests, and influences on ES differed considerably between the focal and the scenario landscapes. Generally, a shift to the "Cash crops", "Coffee investors", and "Food first" scenarios increased the proportion of local, regional and global private organizations that engaged with the landscape. Many of these stakeholders sought to maximize profit through commercializing a few provisioning ES, often relying on regulatory and economic power to influence the landscape. In contrast, a change to the "Biosphere reserve" scenario increased the proportion of non-governmental organizations engaging with the landscape, and drew on stakeholders from multiple governance scales that were interested

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in diverse provisioning, cultural, regulating, and supporting ES. Our findings suggest that future landscapes imply divergent changes in stakeholder constellations and interests, both from proximate and remote locations. Landscape management should consider such possible changes in multi-level stakeholder constellations, interests, and influence. Our methodological approach enriches existing scenario narratives with empirically grounded social and governance layers that can improve proactive land management decisions.

Author summary

Landscapes in the Global South are undergoing rapid changes, which often exacerbates biodiversity loss, reduces ecosystem service supply, and negatively impacts local people, whose livelihoods depend on ecosystem services generated inthe landscape. Due to growing global interconnections, people in geographically distant locations can also be influenced by landscape changes in the Global South—and importantly, their interests in different types of ecosystem services can substantially shape the trajectories of future landscape change. Therefore, sustainable landscape management requires a better understanding of how people from different locations are interested in and influence the ecosystem services in a given landscape, both now and in the future. In this study, we analyzed the types of stakeholders, their interest in and influence on different ecosystem service changes in southwestern Ethiopia, considering both the current landscape as well as four plausible scenarios of the future. Our findings demonstrate how plausible changes in stakeholder constellations could alter, improve or worsen landscape management, biodiversity conservation, and the equitable distribution of the costs and benefits of landscape change. We show that accounting for the social and governance dimensions of landscape change is vital for proactive and sustainable landscape management.

Introduction

Ecosystem services (ES), the benefits that people obtain from nature, are essential for the wellbeing of current and future generations [1,2]. They include different provisioning, cultural, regulating, and supporting services [2]. Growing global interconnections, including trade, have facilitated ES flows across geographically distant landscapes [3–5]. As a result, an increasing number of stakeholders—i.e., groups or individuals who can affect or are affected by a given landscape's ecosystem services [6]—are interested in ES generated in remote landscapes [7–9], with the types of interests varying among stakeholders along the ES supply chain [10–12].

Distal activities and processes thus influence landscapes and their ES [13,14]. Such influences are multi-level [14,15], and can directly target ES management through policy and management decisions, or can indirectly influence landscapes by changing other stakeholders' behaviours. For example, a shift in demand for organic coffee by consumers in coffee-importing countries incentivizes farmers to grow organic coffee in coffee-producing countries such as Vietnam, Columbia, or Ethiopia [4]. The interests and influence of stakeholders in ES generated in remote rural landscapes thus have implications for equity and the environment [4,16–18]. The specific implications are likely to vary according to several factors, including power relations among stakeholders along the ES supply chain [19,20].

With increased recognition of ES flows, stakeholder interactions across multiple spatial scales, and their social and environmental implications, several studies have applied the concept of telecoupling. Telecoupling refers to interlinked socio-economic and environmental interactions across spatial scales [3,21,22], and can be used to map and quantify interregional flows of commodities, species, energy, and information [4,8,23]. However, many existing studies are limited in scope, for example, quantifying only narrow sets of ES [24–26] or only ES generated at present, without considering possible future changes [8,21,24]—i.e., changes in land covers, land uses and ES, as well as associated social and governance changes [20,27].

Addressing the temporal dimension of ES provision is important [28–30] because ES change over time [31] as a direct result of changes in the ecosystems and landscapes from which they are appropriated [32]. For example, a shift in a landscape from multifunctional to homogenized in the future might optimize the supply of a small number of ES [33,34] but would also benefit only few stakeholders, mainly outside the landscape [35].

While the link between landscape features and the generation of specific ES is well-established [36–38], studies that seek to relate future ES provision to (telecoupled) ES appropriation are limited and tend to focus on potential (spatial or temporal) mismatches between supply and demand [30]. Thus, there are considerable theoretical, methodological, and empirical gaps regarding the investigation of how demand for ES will shape trajectories of land use change and the bundles of ecosystem services provided by possible future landscapes. In particular, it is unclear how different stakeholders with interests in different ES and differing agency to affect land use will shape the future appropriation of ES. A better understanding of this is important to identify the institutional scale of interventions required to ensure equitable and sustainable landscape development [12,39,40].

Against this background, we aimed to identify and map how multi-level stakeholders—stakeholders from multiple governance and multiple spatial scales who are connected to a specific landscape—are interested in, and influence ES generated in southwestern Ethiopia, a region rapidly changing and increasingly integrating into global markets [41]. In addition, similar to many other landscapes in the global south, the study area is characterized by rapid social-ecological changes and deterioration of the environmental resource base. As a result, many people whose livelihood directly depends on the ES generated from the landscape are negatively affected, poverty and food insecurity have been increasing, and the rich biodiversity of the landscape is declining [41,42].

We specifically sought to investigate three issues: 1) constellation changes in multi-level stakeholders and their interests in ES generated from the landscape under different landscape scenarios, 2) interest and influence shifts among multi-level stakeholders on ES appropriation under different landscape scenarios, and 3) the spatial patterns of stakeholders' interest and influence in key ES under different landscape scenarios. Our study contributes to the growing literature on telecoupling for ES [3,14,21,22,24], landscape change [28,43,44], and issues of multi-level power relations, social equity, and environmental justice in ES and landscape management [19,45]. Before outlining our detailed (and partly novel) methodological steps, we briefly provide additional theoretical background, including on scenario development, space-for-time substitution, and the analysis of multi-level stakeholders' interest and influence.

Theoretical foundation

In order to investigate the three issues outlined above, we integrated three theoretical building blocks, namely the concept of scenario planning, space-for-time substitution, and the analysis of multi-level stakeholders' interests and influence.

Scenario planning as an approach to assess the future of ES

Scenario planning is an approach that supports engagement with diverse stakeholders to assess past and present drivers of change, identify uncertainties, and generate plausible narratives of landscape trajectories in the future [46,47]. The approach has its roots in military science [48], and is particularly useful in navigating alternative futures in highly uncertain and complex settings, including in the field of environmental management [49–51]. The process of engaging diverse stakeholders facilitates knowledge co-production, addresses questions of equity and legitimacy in landscape planning, and makes outcomes relevant to real-world decision-making [52]. Scenario planning can be used as an exploratory approach [49] or combined with techniques such as backcasting to set a normative goal and support decisions to achieve the desired goal [53,54]. When the outcome of scenario planning is used for normative purposes, understanding biophysical, social and institutional changes provides important input for decision making. Our present study builds on the published outcomes of previous scenario planning work, in which we co-generated with stakeholders four plausible narrative scenarios describing potential future landscape trajectories for a landscape in southwestern Ethiopia [51]. Here, by focusing on stakeholders' interest and influence, we add a new layer of social and institutional aspects to these scenarios: what will the scenarios mean for stakeholders who have an interest and influence in this landscape?

Space-for-time substitution

Space-for-time substitution is an approach that uses contemporary spatial social-ecological system phenomena as a lens to understand temporal processes that are otherwise unobservable [55]. The approach infers future trajectories of social and ecological systems by the analysis of contemporary spatial patterns [56], and is suitable in settings where the temporal process is inaccessible [55–57]. Historically, space-for-time substitution has been widely used in landscape ecology [55,58], for example, to predict the long-term effects of climate change on nutrient cycling [59], future bird species distribution [60], or the future of aquatic ES [61]. However, space-for-time substitution has rarely been used in the social sciences. Space-for-time substitution has been contested in settings where the rate of ecological change is rapid [62]. However, the approach is useful when it is the only reasonable way to anticipate how a given change through time might influence a particular place [57,63]. Based on this reasoning, we used space-for-time substitution in a social-ecological context to understand multi-level stakeholder constellations, interest, and influence around ES generated from possible future landscapes in southwestern Ethiopia. To approximate four scenarios of possible future landscapes, we used existing 'proxy landscapes' that represented many of the key features of the possible future scenario landscapes.

Multi-level stakeholder interest and influence

Stakeholder analysis has been used for many decades in different fields, including environmental management, both for normative and instrumental purposes [64]. In the context of ES flows, stakeholder interest and influence occur at multiple spatial scales involving local, regional, national, and global scales and governance (institutional) levels, including municipal, district, zonal, regional, national and global [65,66]. Stakeholders' interest around ES is often narrowly conceptualized as the benefit a stakeholder obtains from ES [64,66]. However, a stakeholder can be interested in a given ES not only because bundles of ES benefits flow to the stakeholder, but also because the stakeholder has a mandate to manage the ES, or because the provision of a given ES indirectly influences the stakeholder—for example the influence of food production on biodiversity is of interest to conservation NGOs [13,29]. Such interests vary among stakeholders at different spatial scales and governance levels, and differ in extent or strength. For example, at the national level, private entrepreneurs may be interested in economic gains from coffee-related ES, while local stakeholders such as non-governmental organizations or farmers may be interested in preserving the cultural practices associated with, or the genetic material of, local coffee varieties. Understanding the type and strength of stakeholders' interest in a given ES is important to make well-informed landscape management decisions [38]. Stakeholder influence on ES relates to stakeholder power [67,68], that is, the capacity of a stakeholder to exert influence directly on the ES or indirectly on other stakeholders who supply the ES [19,22]. This notion of influence is often captured in the literature as 'power over' or 'relational power' [68–70]. Such influences differ in the sources of power, the means, and the strength of influence [19]. Our study sought to understand how interest and influence of stakeholders in the ecosystem services of a given landscape might change under different future scenarios of landscape change.

Methods

This study followed a mixed-methods approach. It combined multi-level quantitative mapping of stakeholders' interest in and influence on ES in five landscapes–one baseline landscape (hereafter "*focal landscape*") and four (space-for-time) proxy landscapes related to future scenarios developed for the focal landscape over the coming 20 years–as well as qualitative data obtained through interviews conducted between January and April 2020. First, we mapped the interest and influence of stakeholders on key ES across multiple levels in the five landscapes. We then combined these findings with the qualitative data to characterize influence and interest patterns in each of the four proxy 'future' landscapes against the current focal landscape.

Site and sample selection

The study was conducted in southwestern Ethiopia, covering stakeholders at the global, national, regional, zonal, district (hereafter woreda), and municipal (hereafter kebele) levels. This study built on a previous scenario planning study. Jiren et al. [51] identified four plausible scenarios for the Jimma landscape in 2040. Summaries of the current situation and the four scenarios are provided in Fig 1; please refer to Jiren et al. [51] for full details of the scenarios and the research involved. The current focal landscape consisted of three woredas: Gumay, Gera, and Setema [51]. These woredas are found within a 100 km radius from Jimma town (Table A in S1 Text). The focal landscape is rich in biodiversity and captures the wild gene pool of endemic coffee (*Coffea arabica)*. The landscape covers different land use systems involving agricultural land, pastureland, and forest. Local smallholders produce cash crops, food crops, rear livestock, and collect forest products. Although there was variation within the focal landscape in the provision of infrastructure, such as access to roads and markets, access to basic health and agricultural extension services was available throughout the landscape [71].

Using the principle of space-for-time substitution, we selected four proxy landscapes near the focal landscape to represent the four scenarios. First we identified and characterized key biophysical and socio-economic features of the four scenarios from their narratives [51]. Then, we discussed these key features of the scenarios with local experts from Jimma zone who had participated in developing the scenarios. Based on the experts' recommendations and our prior understanding of the area, we then identified four proxy woredas that closely resembled key features of the four scenarios in terms of the social and ecological features (Table A in S1 Text). Experts helped us to identify woredas whose past trends, current features, and future land use plans best reflected features of the four scenarios. For example, Omo Nada woreda, the landscape proxying the 'Food first' scenario landscape, has been formally demarcated as a 'food crops specialized landscape' in government development plans.

Seka Chekorsa woreda was used as a proxy landscape for the "Gain over grain: Local cash crops" (hereafter "*Cash crops*") scenario. This woreda is located 18 km from Jimma. It is the

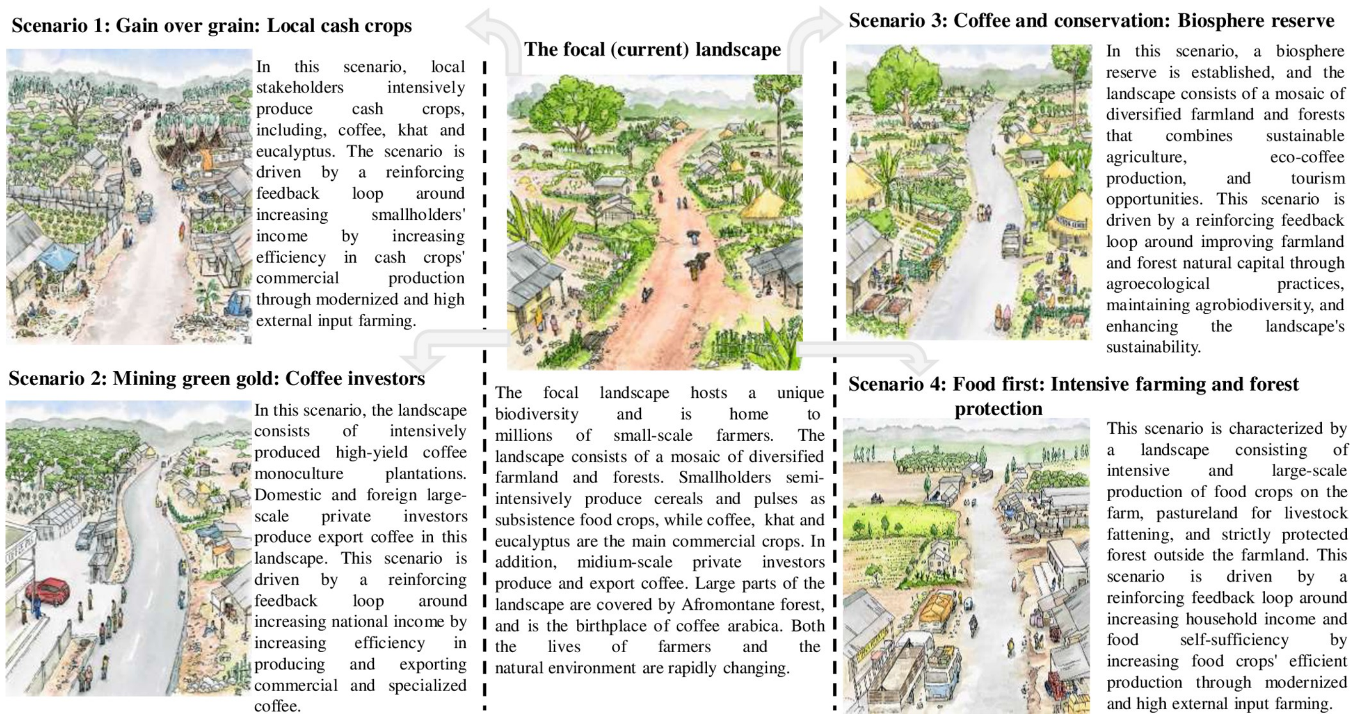

Fig 1. Landscape features and a summary of the focal and four scenario landscapes (Summarized from Jiren et al. 2020).

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leading cash crop production area in Jimma zone, and its land use system consists of fast-growing cash crops such as coffee, khat, fruits, and eucalyptus. In addition, livestock rearing and food crop production serve as means of livelihood in Seka Chekorsa [72] (Table A in S1 Text).

Limmu Kosa woreda was used as a proxy landscape for the scenario "Mining green gold: Coffee investors" (hereafter "*Coffee investors*"). Limmu Kosa woreda is 75 km from Jimma. The land use system dominantly consists of coffee production and is known for its large-scale coffee investment. The woreda hosts the largest number of private coffee investors in Jimma zone. Coffee, food crops, mining, and livestock rearing were the dominant means of livelihood for people in the woreda [72] (Table A in S1 Text).

Yayu woreda was used as a proxy landscape for the "Coffee and conservation: Biosphere reserve" (hereafter "*Biosphere reserve*") scenario. Yayu woreda is in the Illubabor zone, 38 km from Mettu, the capital of the Illubabor zone. This proxy landscape is multi-functional involving a biosphere reserve and agricultural production areas. It was the nearest woreda to our focal landscape (within the same regional state) where a biosphere reserve currently exists. Most people in Yayu woreda practice diversified farming–coffee, food crops, fruits, livestock rearing, and non-timber forest products were the main livelihood activities [72] (Table A in S1 Text).

Omo Nada woreda was used as a proxy landscape for the scenario "Food first: Intensive farming and forest protection" (hereafter "*Food first*"). Omo Nada woreda is 71 km away from Jimma. Land use features mainly intensive agricultural land, pastureland, and forest. The majority of local people produce food crops such as teff, sorghum, and maize and engage in livestock rearing as a means of livelihood [72] (Table A in S1 Text).

After selecting these proxy landscapes, we interviewed key stakeholders in all five landscapes. We began stakeholder identification from the focal landscape. Here, we followed a snowball sampling approach [73], starting at the woreda level with the Bureau of Agriculture and Natural Resources, which holds a central position and linking role at the woreda level [74]. This stakeholder then mentioned other stakeholders interested in the different ES generated from the landscape horizontally (within the same woreda) and vertically (at lower kebele level and higher levels and spatial scales, from zone to global). Following this procedure, we identified and interviewed stakeholders who had a stake in one or more of the ES generated from the focal landscape (Fig 2).

We followed the same procedure in the proxy landscapes. In total, we identified 189 different types of stakeholders for the focal and four proxy landscapes (Table B in S1 Text). Of these, we interviewed 122 stakeholders. We did not directly interview the remaining stakeholders because some were unreachable due to geographical barriers, were unresponsive to our queries, or were unwilling to be involved. Since these stakeholders were nominated by other stakeholders as being interested in or influence on one or more ES, their interest and influence on ES were obtained through a peer rating technique (see next section for details). Many stakeholders above the zonal level were interested in and simultaneously influenced ES generated from many different landscapes. For example, the Zonal Bureau of Agriculture and Natural Resources was interested in and influenced coffee ES generated from the focal and three of the proxy landscapes.

Data collection and analysis

We collected data through semi-structured interviews; each interview lasted approximately one hour. The interview questions were first pre-tested with experts who have knowledge of the subject and an understanding of the social context of the study area. We then piloted the questions with a small number of stakeholders prior to the commencement of the actual stakeholder interview. Changes were made at every step to ensure that the final version was reliable and readily understandable for stakeholders. Finally five key themes guided each interview in the focal and proxy landscapes (Fig 2).

First, we started stakeholder interviews by asking about stakeholder characteristics, including key roles in ES management, functions, and mandates in the landscape. Second, we asked about the types of ES the stakeholder was interested in or had influence over in the landscape. Here, we asked interviewees an open question to list the different ES generated from the landscape which the stakeholder had interest in or influence over. At this point, we described stakeholder interest as the stakeholder obtaining benefit from, or being affected by decisions related to it, or having a mandate in the management of a certain ES. Similarly, influence over ES was defined to exist when a stakeholder directly engaged in ES management decisions, or indirectly influenced an ES through controlling, restricting, or rewarding other stakeholders. Third, we asked the type of interest and strength of interest a given stakeholder had in each of the listed ES. Respondents rated their perceived strength of interest as (1) = very low, (2) = low, (3) = moderate, (4) = strong, or (5) = very strong. "Very low interest" meant the ES had virtually no priority for the stakeholder, while "very strong interest" meant the ES was centrally important and irreplaceable for the stakeholder. Fourth, we asked about the stakeholder's relative influence on each of the ES. Specifically, we asked whom and how the stakeholder influenced the ES and the strength of influence. Respondents rated the strength of influence as (1) = very low, (2) = low, (3) = moderate, (4) = strong, or (5) = very strong. "Very low influence" signalled that a stakeholder had a minimal direct or indirect influence on a particular ES, whereas "very strong influence" denoted when the stakeholder perceived almost complete direct control over the ES or indirect control via their influence on other stakeholders involved in ES appropriation. Fifth, we obtained peer ratings for the interest and influence of this and other

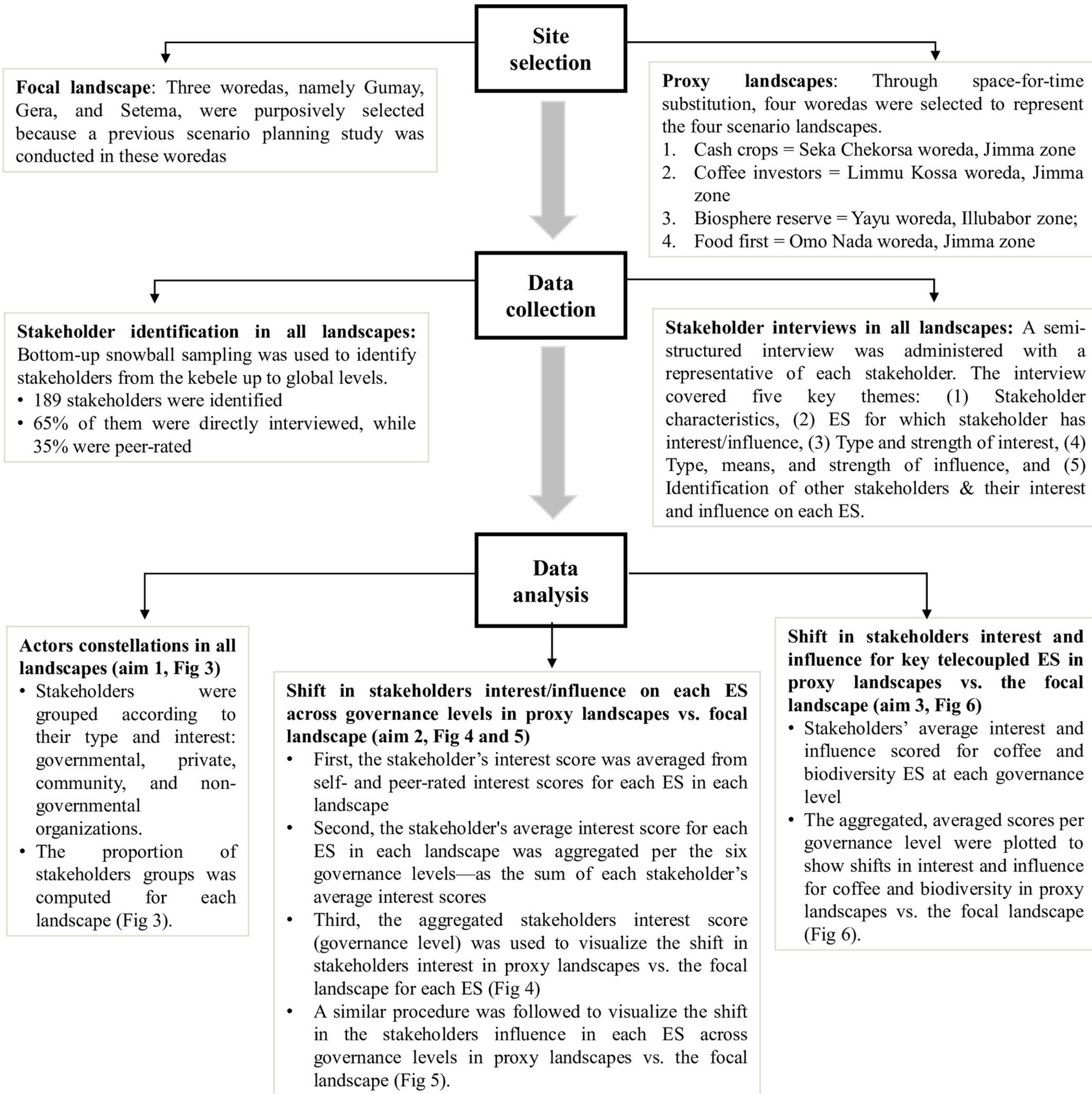

Fig 2. Schematic presentation of methods.

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stakeholders by identifying further relevant stakeholders and asking them to rate their peer stakeholders. Specifically, we asked our current stakeholder to list other stakeholders from the same or different levels interested in or influencing each of the ES listed. For these stakeholders, we followed the same procedure as explained above and then asked them to rate the strength of interest and influence of each stakeholder they mentioned.

For data analysis, we first considered the quantitative data on the strength of stakeholder interest and influence for each of the ES separately for the focal and the four proxy landscapes.

We then followed five main steps for the quantitative data analysis. First, to compare the shift in stakeholders' interest and influence on ES, we standardized the naming of ES across all landscapes. Respondents provided different names for the same type of ES across study landscapes. For example, for the sake of simplification and comparison, all food crops produced from the farmland were considered as "cereals," all products from the forest such as spices, honey, timber, and non-timber forest products were grouped under "forest products," and maintaining the genetic diversity of trees and crops, wildlife and wildlife habitat services were grouped under "biodiversity".

Second, to identify how the constellation of stakeholders with specific interests in ES changed in the proxy landscapes compared to their constellation in the focal landscape (aim 1), we grouped stakeholders according to their types and interests. Accordingly, stakeholders were grouped within four broad types. 1) Community-based organizations (CBOs) comprised local people and their associations, such as producers, coffee cooperatives, and unions. 2) Private organizations (POs) comprised local private traders, national distributors, wholesalers, retailers, exporters, and global companies involved in the trade and supply of ES. 3) Governmental organizations (GOs) comprised formal public organizations with a strong mandate for the administration, production, conservation, and marketing of ES. 4) Non-governmental organizations (NGOs) comprised indigenous, bilateral and multi-lateral international organizations (Table C in S1 Text). We then computed the proportions of the types of stakeholders for each (proxy and focal) landscape and visualized the change in proportions in proxy landscapes relative to the constellation in the focal landscape.

Third, to explore shifts in stakeholders' interest on each ES in the proxy landscapes relative to the focal landscape (aim 2), we calculated each stakeholder's average interest score from self-rated and peer-rated scores combined for each ES. For example, a stakeholder with interest scores of 4 (self-rating) and 3 (peer-rating) for coffee in the focal landscape obtained a 3.5 for the interest on coffee for this landscape. After computing stakeholders' average scores for each ES in each landscape, to visualize the change in stakeholder interest on each ES in the proxy landscape relative to the focal landscape at each governance levels, we aggregated stakeholder average interest scores to each of the six governance levels—i.e., kebele, woreda, zone, region, national and global levels for each of the ES under the five landscapes. For example, kebele level stakeholders' interest on coffee in the focal landscape was calculated as the sum of all stakeholders' average interest scores at this governance level. We then used this summed interest score to visualize and contrast how stakeholders' interest shifted, for each ES, in the proxy landscapes relative to the focal landscape.

Fourth, we followed a similar procedure as in the third step to explore and visualize shifts in stakeholders' influence on each ES in the proxy landscapes relative to the focal landscape (aim 2).

Fifth, to explore how the aggregate interest and influence over key telecoupled ES shifts across governance levels in the proxy landscapes against the focal landscape (aim 3), we calculated the average score of stakeholder interest per governance level similar to the calculations for influence scores that were described above, but without summing them up to an aggregate score. We then plotted the average interest scores, together with averaged but not aggregated influence scores, for each governance level in an interest-influence matrix. We here focused on the changes for the coffee and biodiversity in the proxy landscapes against the focal landscape. We used *ggplot2* in R for visualization [75].

The qualitative data on the types of stakeholders' interests and the types, means, and sources of each stakeholders' influence were first transcribed from field notes and audio recordings. The transcripts were then coded using MAXQDA [76] for subsequent qualitative content analysis [77]. Here, we initially deductively created five primary nodes representing the five landscapes. Next, we created sub-nodes under each of the primary nodes related to stakeholder types, levels, type of interest, and means of influence. We then inductively created another layer of nodes under the sub-nodes in which specific types of interest and influence were coded and classified.

Results

Overview of stakeholders' interest in ES

Our results showed that stakeholders were interested in or influenced eight types of ES: coffee, eucalyptus, khat, cereals, livestock, fruits and vegetables, forest products, and biodiversity. Stakeholders in the focal, cash crops, and biosphere reserve landscapes were related to all ES types. However, biodiversity was not of interest in the coffee investors landscape. Similarly, coffee and khat were not ES of interest in the food first landscape. The strong interest in eucalyptus and khat was mainly held by local stakeholders, while stakeholders from all governance levels were interested in or influenced the other ES (Figs 3 and 4).

Stakeholder constellation and interest

We found that stakeholder groups' relative dominance and interest in ES varied between landscapes.

Focal landscape. A total of 109 stakeholders from local to global levels were interested in ES generated from the focal landscape. Among these, GOs accounted for the highest proportion (60%, n = 65) followed by POs (18%, n = 20), CBOs (12%, n = 13) and NGOs (10%, n = 11) (Fig 3).

Regarding stakeholders' interest in ES across governance levels, stakeholders below the zonal level were strongly interested in all ES (Fig 4). In contrast, stakeholders above the national level were only interested in coffee and biodiversity (Fig 4). In terms of stakeholder groups interest, GOs from kebele to the national levels were interested in all ES except eucalyptus and khat (Fig 4). Interviews indicated that GOs had multiple interests, including facilitating sustainable landscape management and biodiversity conservation, enabling efficient

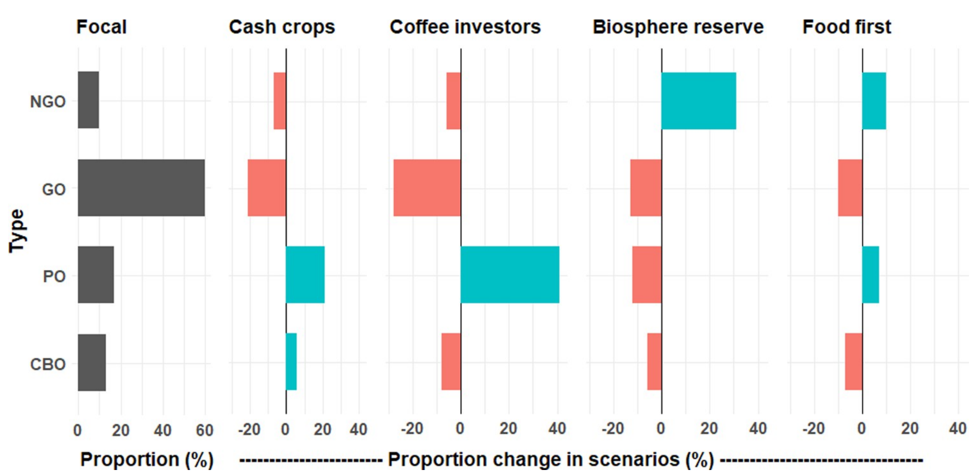

Fig 3. Changes in the constellation of stakeholder groups in the four scenarios, represented by proxy landscapes, compared with the current, focal landscape. Proportions and changes in proportions are displayed for GO = government organizations, NGO = non-governmental organizations, PO = private organizations, and CBO = community-based organizations. The colors of the bars visualize the direction of change: red = reduced proportional presence, cyan = increased proportional presence.

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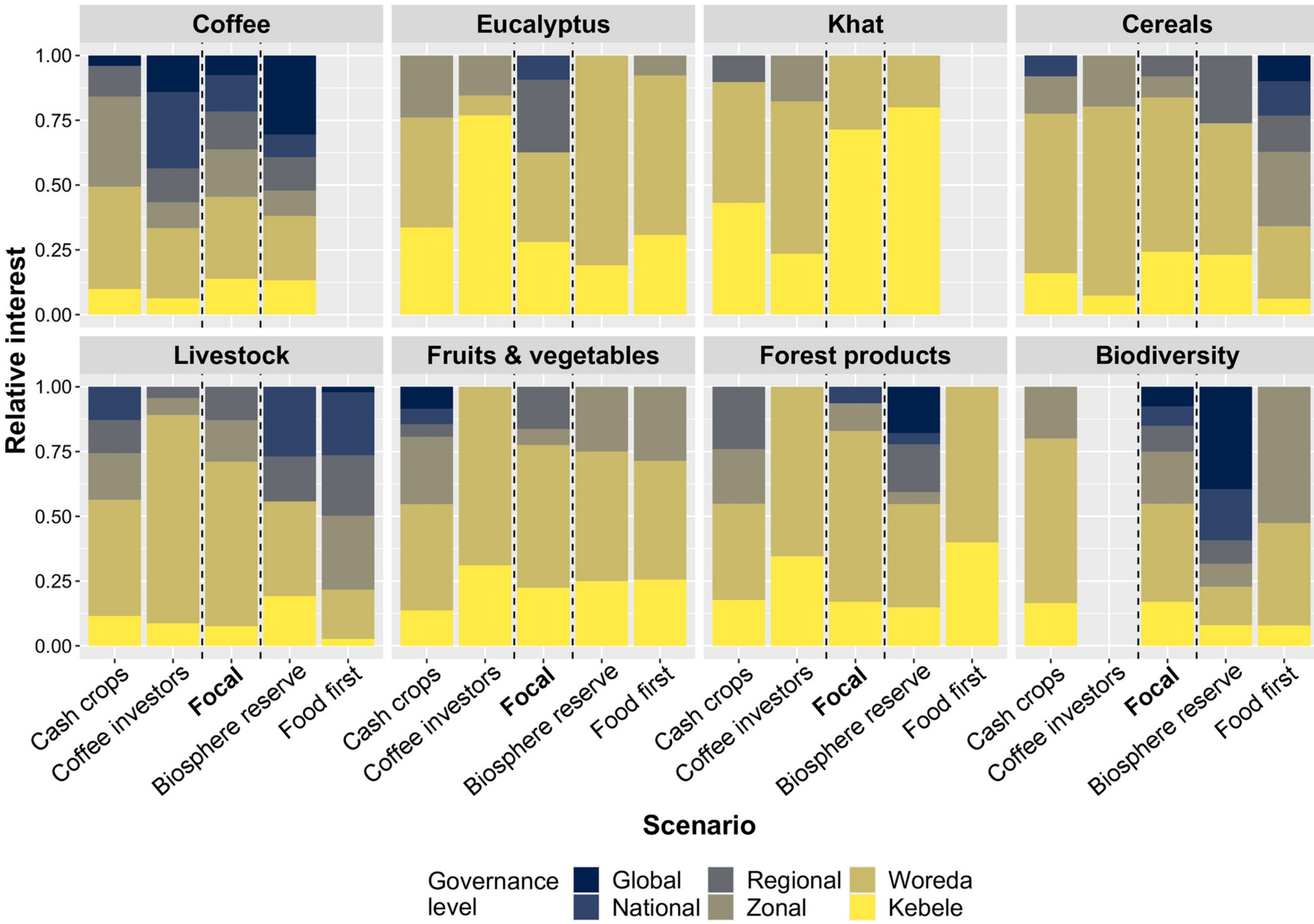

Fig 4. The proportional interest of stakeholders from different governance levels on each of the eight ES in the focal landscape (middle bar) and in the four scenarios, as represented by proxy landscapes.

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production and ES flow, improving local people's livelihoods, and revenue generation from the ES. However, due to ecological and social concerns, no GOs at any governance level expressed interest in the production of eucalyptus and khat. POs at all levels were primarily interested in tradeable ES, including coffee, livestock, eucalyptus, khat, and food crops (Fig 4), mainly as a source of income and profit. However, local scale POs generated income and profit from the supply of raw products such as coffee beans, while regional and national POs generated revenue through value-adding processes, including grinding, brewing, and packaging. In addition to financial interests, some global POs, such as the Royal Coffee Company, were strongly interested in importing organic and quality coffee to the United States of America. CBOs from the kebele level had an interest in all ES (Fig 4), and their interest involved food self-sufficiency (e.g., through surplus production of food crops, livestock, forest products), income generation (e.g., from the production and trade of coffee, eucalyptus, and khat), and cultural importance (e.g., from khat and coffee). Finally, NGOs were primarily interested in coffee and biodiversity (Fig 4), and had a similar interest to GOs, mainly facilitating the sustainable production, marketing, and conservation of ES.

Cash crops vs. focal landscape. In the cash crops landscape, 77 stakeholders were interested in one or more ES (Table B in S1 Text). Among these stakeholders, POs and GOs constituted 40% each (n = 31 each), CBOs 13% (n = 10), and NGOs 7% (n = 5). Thus, compared with the focal landscape, a shift towards this landscape would lead to a decline in the proportion of NGOs and GOs and an increase in the proportion of POs and CBOs (Fig 3).

In terms of stakeholders' interest across governance levels, as in the focal landscape, stakeholders below the zonal level had a strong interest in all ES (Fig 4). However, stakeholders above the regional level were interested mainly in coffee, livestock, and fruits and vegetables (Fig 4). In terms of the interest of stakeholders groups, we found that the interest of GOs, POs, and CBOs in this landscape was generally similar as in the focal landscape. However, few exceptions existed. First, unlike in the focal landscape, GOs in the cash crops landscape were interested in eucalyptus and khat primarily due to the growing financial and cultural values of these ES. Second, POs in the cash crops landscape focused more strongly on local cash crops, namely eucalyptus, khat, and fruits, through trade with adjacent woredas. Finally, slightly different from the focal landscape, NGO interest in the cash crops involved establishing global market linkages between CBOs and particular countries funding the NGOs. For example, the Japan International Cooperation Agency (JICA) facilitated quality coffee imports to Japan by linking local producers to a Japanese coffee importing company, the Ueshima Coffee Company (UCC).

Coffee investors vs. focal landscape. From a total of 57 stakeholders interested in the ES of the coffee investors landscape, POs accounted for 51% (n = 29), followed by GOs, CBOs, and NGOs, which constituted 35% (n = 20), 11% (n = 6), and 3% (n = 2) respectively (Table B in S1 Text). Compared with the focal landscape, a shift towards this type of landscape would result in a reduced proportion of all groups of stakeholders except for POs (Fig 3).

Regarding governance levels, similar to focal landscape, stakeholders below the zonal level had a strong interest in all ES (Fig 4) except for coffee, which was the only ES in which global stakeholders had a strong interest (Fig 4). In terms of interest of stakeholders groups, in contrast to the focal landscape, GOs in this landscape were primarily interested in optimizing land use efficiency, facilitating large-scale private coffee farms, and increasing national earnings from coffee export and labour employment. Similarly, POs were interested in maximizing profit and increasing national earnings from the production, supply, and export of coffee. Unlike POs in the focal landscape, local POs were mainly coffee producers, investors, exporters, and global coffee companies. CBOs and NGOs had similar interests as in the focal landscape.

Biosphere reserve vs. focal landscape. From a total of 67 stakeholders interested in the ES generated from the biosphere reserve landscape, GOs accounted for 43% (n = 29), followed by NGOs, CBOs, and POs, which constituted for 30% (n = 20), 15% (n = 10), and 12% (n = 8) respectively (Table B in S1 Text). A key shift was that the proportion of NGOs from local to the global levels increased, including UNDP and UNESCO. The proportion of other stakeholder groups decreased compared with the focal landscape (Fig 3).

In terms of governance levels, except for coffee and biodiversity ES, stakeholders below the zonal level had a strong interest in all ES (Fig 4). GOs had a similar interest to the focal landscape; distinctly strong interest, though, was expressed for nature conservation, preserving arabica coffee, carbon sequestration, and improvement of local people's livelihoods–for example, through increasing incomes by linking local people to global markets for certified forest and organic coffee, or global carbon markets. Unlike in the focal landscape, global level NGOs had a stronger interest in coffee, forest products, and biodiversity of this landscape (Fig 4). Their interest involved preserving arabica coffee, carbon sequestration, improving local people's livelihoods, and maintaining the biosphere reserve. Finally, POs and CBOs pursued similar interests as in the focal landscape.

Food first vs. focal landscape. From a total of 74 stakeholders interested in ES from the Food first landscape, GOs accounted for the highest proportion, 45% (n = 33), followed by POs (26%, n = 19), CBOs (13%, n = 10), and NGOs (16%, n = 12) (Table B in S1 Text). Compared with the focal landscape, a shift towards this type of landscape would result in an increased proportion of POs (mainly domestic) and NGOs and a decline in the proportion of GOs and CBOs (Fig 3).

In terms of the governance level, except for coffee and khat, similar to the focal landscape, stakeholders below the zonal level had a strong interest in all ES (Fig 4), and stakeholders above the regional level had interest only in the cereals and livestock ES (Fig 4). However, no stakeholder was interested in the coffee and khat ES from this landscape (Fig 4). In terms of interest of stakeholder groups, qualitative interviews showed that GOs had similar interests to those in the focal landscape, but distinct key interests of many GOs were related to intensifying food production–e.g., facilitating surplus production for household and national food self-sufficiency, increasing revenue, competitive food crops market, protection of smallholders, or sustainable landscape management. Similarly, POs had a similar interest as in the focal landscape but were specifically interested in income generation and profit-making by participating in food crop marketing. In contrast, CBOs were interested in the surplus production of food crops for self-sufficiency and income generation. NGOs were mainly production-oriented; as such, their interest was in increasing the production and marketing of food crops to improve household and national food self-sufficiency and maintain and maintain regulating ES such as soil fertility.

Relative influences of stakeholders across the scenarios

Stakeholders from different spatial scales influenced ES generated in the focal and proxy landscapes (Fig 5). In the focal landscape, stakeholders below the zonal level had the highest influence over the eight ES (Fig 5), and the majority of them were GOs (Fig 3), whose influence was primarily driven by their formal positions in the enforcement of land use and ES trade policy. Specifically, they influenced CBOs and POs using administrative and regulatory power, such as revocation of land ownership from non-complying local people or suspension of the trade license of non-conforming POs. POs also had a strong influence at this level, but specifically on traded ES such as coffee, eucalyptus, and khat (Fig 5). They influenced CBOs mainly through determining the market volume of ES. CBOs directly influenced the production and supply of ES, but had the least influence on ES that flows to the national or global level (Fig 5). In contrast, stakeholders above the regional level had a relatively strong influence on ES demanded and traded at national and global scales—i.e., coffee and biodiversity (Fig 5). For instance, GOs above the regional level, such as the Coffee and Tea Authority, influenced other stakeholders by setting production and trade agendas, monitoring their enforcement, and facilitating linkages between exporters and global importers. In addition, POs above the regional levels such as coffee exporters relied on financial capital to influence other stakeholders who supply the ES. Global NGOs indirectly influenced ES, for example through providing financial and technical support to local coffee producers.

Cash crops vs. focal landscape. As in the focal landscape, stakeholders below the zonal levels had the strongest influence on all ES in the cash crops landscape (Fig 5), but POs were found strongly influential on the locally traded ES, eucalyptus and khat (Fig 5). In particular, as in the focal landscape, POs below the zonal level had a strong advantage of financial, market networks, and information, and thus directly influenced ES suppliers (i.e., CBOs) through determining market volume and prices of ES. In this landscape, CBOs and NGOs had the least influence on ES as a whole (Fig 5). In contrast, stakeholders above the regional level influenced

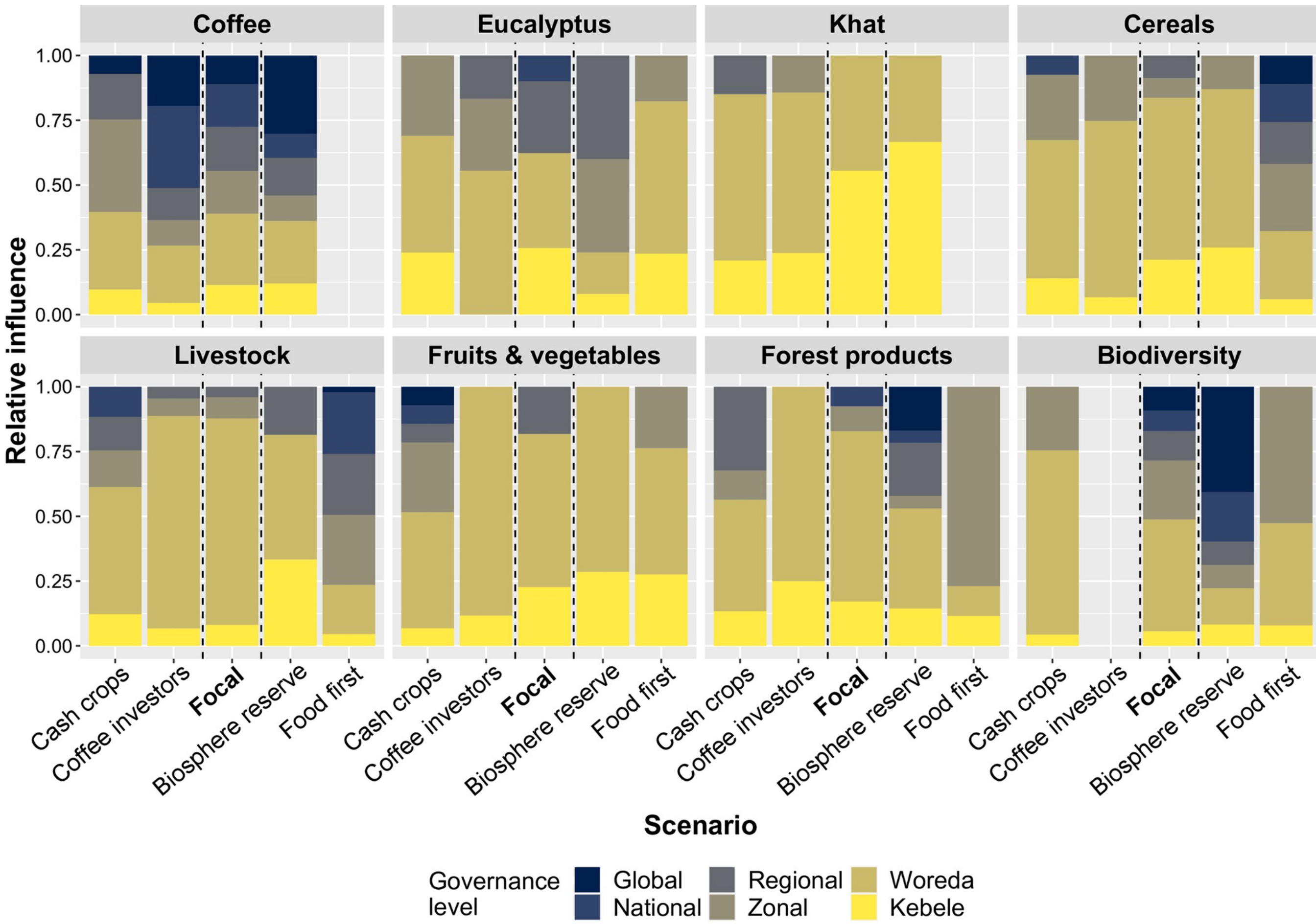

Fig 5. The proportional influence of stakeholders from different governance levels on each of the eight ES in the focal landscape (middle bar) and in the four scenarios, as represented by proxy landscapes.

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nationally or globally traded ES, namely fruits and vegetables, coffee, and livestock (Fig 5). GO's influence was similar to the focal landscape. A key change in this landscape was that global level companies (POs) directly influenced local fruit producers through a contract farming scheme. An example was a contractual agreement between avocado producers and Middle Eastern companies, where the former complied with the quality standards set by the latter global company to benefit from market access as well as technical and financial gains.

Coffee investors vs. focal landscape. In the coffee investors landscape, stakeholders below the zonal level had a relatively strong influence on all ES except for coffee (Fig 5). In contrast, stakeholders above the regional level had the strongest influence on the key ES in this landscape, i.e., coffee (Fig 5). GOs above the regional level influenced other stakeholders in the same way as in the focal landscape. However, some stakeholders, such as the Investment Bureau and Commission, directly influenced CBOs through decisions related to land allocation for private investors. Similarly to the focal landscape, POs above the regional level, such as exporters and global companies, relied on financial capital and used market instruments such as price incentives to influence ES suppliers. For instance, global POs such as the Royal Coffee Company of the USA used market instruments, including market and price incentives, to directly influence coffee-producing CBOs to comply to their pre-set quality standards.

Biosphere reserve vs. focal landscape. In the biosphere reserve landscape, stakeholders below the zonal level more strongly influenced ES than in the focal landscape. Indeed, CBOs had the strongest influence on ES here compared to all other landscapes (Fig 5). Stakeholders above the regional level, mainly the global NGOs involving multi-lateral institutions such as the UNHCR and UNDP, had the highest influence on key ES, namely coffee, forest products, and biodiversity (Fig 5). These global stakeholders directly influenced CBOs by providing technical, organizational, and financial incentives for the sustainable production of coffee and biodiversity. For instance, CBOs around the Yayu biosphere reserve were financially incentivized from global fair trade and supply of certified organic coffee, a market created due to the recognition of the biosphere reserve by global institutions. In addition, GOs above the regional level also strongly influenced the three key ES (Fig 5), mainly through setting conservation agendas and by monitoring local stakeholders' compliance.

Food first landscape vs. focal. In the food first landscape, stakeholders below the zonal level influenced locally demanded ES such as forest products, biodiversity, eucalyptus, and fruits (Fig 5). These stakeholders exercised influence in the same way as in the focal landscape. CBOs had only a minor influence on the key ES produced in the food production landscape (Fig 5). In contrast, stakeholders above the regional level, involving GOs and POs, had the highest influence on the two key ES in the landscape, cereals, and livestock (Fig 5). These stakeholders had similar means of influence and sources of power as in the focal landscape. However, POs, utilized advantages such as social networks (through local agencies or brokers) and market information asymmetry to determine the volume and prices of ES supplied by the CBOs. In addition, NGOs, such as the Bill and Melinda Gates Foundation, founded a semi-autonomous Agricultural Transformation Agency, which influenced CBOs in favor of intensive production of food crops through capacity building, market linkages and supply of inputs.

Changes in the interest and influence over key ES across landscapes

Stakeholders' interests and influence for a given ES were generally complementary in all landscapes. That means stakeholders with a high interest usually also had a high influence on a particular ES (Figs 4 and 5). Fig 6 shows the changes of stakeholders' interest and influence for two telecoupled ES, namely coffee and biodiversity.

For coffee, the interest and influence of stakeholders at all governance levels converged around mid-range values in the focal landscape (Fig 6). Stakeholders below the zonal level had a moderate interest but relatively strong influence on coffee. Compared with the focal landscape, the interest and influence on coffee by stakeholders at all governance levels decreased in the cash crops landscape, but it increased in the coffee investors landscape (Fig 6). A mixed result emerged for coffee in the biosphere reserve landscape: interest and influence of stakeholders above the regional level increased, while they both decreased for woreda stakeholders (Fig 6).

For biodiversity, the interest and influence of all stakeholders appeared to be relatively low in the focal landscape (Fig 6). Regional and national stakeholders had comparatively higher interests and influence than other stakeholders in the focal landscape (Fig 6). While minor changes in interest and influence occurred for biodiversity in the cash crops and the food first landscapes, stakeholder interest and influence at all governance levels increased in the biosphere reserve landscape. Here, stakeholders from the kebele, regional, and global levels had a particularly high interest and influence (Fig 6).

Discussion

This paper demonstrates a novel methodological approach to assess the consequences of landscape change on stakeholders and governance. Using space-for-time substitution, we

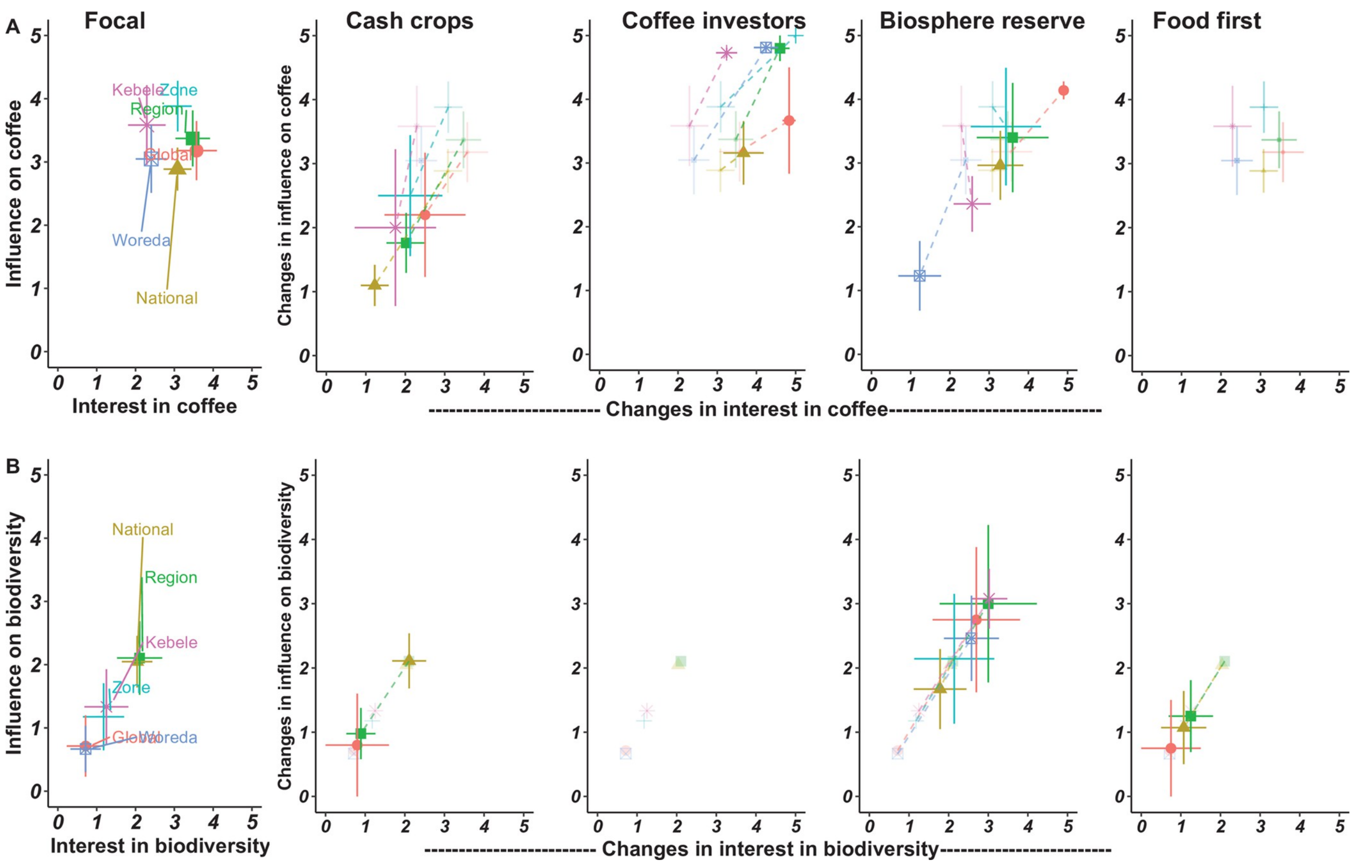

Fig 6. Interest and influence of stakeholders from different governance levels in the current, focal landscape (left panels) and changes in their interest and influence in the four scenarios, as represented by proxy landscapes. Interest and influence are mapped for two ES, (A) coffee and (B) biodiversity. Positions of stakeholders are calculated as means of interest and influence per governance level for a given ES in the landscape.

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investigated changes in interest and influence of multi-level stakeholders in plausible future landscapes, as identified by scenario planning. Our empirical work revealed that stakeholder constellations, interests in, and influences over ES would shift markedly under alternative future scenarios. For example, local, regional and national, and global level POs were predominant in the cash crops, food first and coffee investors landscapes. These stakeholders' interest primarily involved profit maximization from few commercial crops, and the influence of these stakeholders was very strong in the respective landscape. In contrast, a shift to the biosphere reserve landscape would increase the proportion and influence of both local and multilateral NGOs, whose interests relate to increasing smallholder incomes from sustainable ES appropriation and conservation of the genetic resources of the landscape.

Our findings thus show that changes in stakeholder constellations, interest and influence can have implications for local equity and resource conservation–better understanding these changes, in turn, is important for proactive landscape management decisions. This includes having a better idea about which stakeholders are key to transitioning towards a desirable future land use scenario, as well as better understanding which stakeholders might be marginalized through future land use change.

Implications of landscape change for social equity

Our results showed that a shift toward a future landscape dominated by cash crops improves the match between the spatial scale at which key ES, such as eucalyptus and khat, are generated and the location of stakeholders with dominating interest and influence. This spatial fit may provide economic benefits to local stakeholders, improve local people's agency over key ES and contribute to poverty alleviation [11,45]. In addition, empirical studies in sub-Saharan African countries indicate that smallholder commercialization of cash crops such as eucalyptus and khat can diversify livelihoods, and that local stakeholders who participate in this development are often generating a relatively higher income [78,79].

However, despite the economic benefits, cash crop-dominated landscapes could lead to a number of socio-economic problems. First, at the local scale, the presence of stakeholders with competing economic interests and unequal power could jeopardize social equity—that is, it may lead to highly uneven distributions of the costs and benefits of landscape change among the different interested and influencing stakeholders. Particularly, our study indicated that POs and GOs had strong economic and regulatory power, while CBOs had a negligible influence in such cash crop-dominated landscapes. The absence of influential CBOs, asymmetric market information, and unbalanced economic power among local stakeholders, may result in benefit capture by a few powerful POs at the expense of majority of CBOs, who ultimately would end up bearing the highest costs associated with a shift towards a cash crop-dominated landscape. Ample examples from developing countries exist, such as oil palm production in Indonesia and non-timber forest products in southern African countries, where inequity increases in such landscapes [38,80]. Second, some cash crops produced from our specific scenario landscape, especially khat, can lead to adverse social and economic problems, including public health and socio-economic problems—examples are increased school dropout by khat chewers, work absenteeism, social conflict, and increased financial problems due to purchasing khat [81,82].

In contrast, a shift to the coffee investors and food first landscapes changes the spatial scale of influential stakeholders further away from the landscape, and interest is mostly commercial and focused on a few nationally and globally demanded ES. Overall, these two landscapes mainly respond to market forces at a higher spatial scale, correspond to the national growth model of 'export promotion and import substitution' [83], and reflect the overall development pathway of Ethiopia [84,85] and most other sub-Saharan African countries [86]. Such landscapes also provide economic benefits to investors and participating stakeholders along the ES supply chain and increase national export earnings. Emerging economies such as Brazil, for example, have thus seen substantially growing national income resulting from a large-scale expansion of private investment in nationally and globally demanded ES, as well as increased production efficiency and global market integration [87,88]. However, a shift to these types of landscapes is also likely to lead to significant equity problems. First, the increased presence of private investors from outside the landscape usually increases the appropriation of smallholder land and land grabbing by investors [89], leading to increased landlessness of local people and a loss of local sovereignty over ES [90]. Second, benefit capture by influential stakeholders from outside the landscape and their trade manipulation increase inequality and exacerbate social inequity.

We showed that a shift to the biosphere reserve landscape indeed supports stakeholder plurality and the multiplicity of interests and influence over diverse ES of local to global importance. In the biosphere reserve landscape, local stakeholders, including CBOs, had a relatively strong influence on ES. Such landscapes are based on the notion of agro-ecological production that balances conservation and development goals. Various studies link such landscapes to increased social equity in benefit-sharing among stakeholders [13], mainly because of local people's increased command over resources, technical, financial, and market support from non-state global actors, fair trade, and strong land tenure security [91]. However, such landscapes may not facilitate the accelerated economic gains for a few stakeholders seen in the commercialization of landscapes and their ES [92].

Implications of landscape change for biodiversity conservation

Regarding biodiversity, a shift towards landscapes that focus on locally or investor-owned cash crops or on food crops (i.e., the cash crops, coffee investors, and food first landscapes) would shift stakeholders' interest and influence to predominantly provisioning ES. These landscapes specialize on a few provisioning ES that can be traded [51], and landscape management is thus usually driven by stakeholder interests such as land use optimization, production efficiency, and profit maximization. Theoretically, intensification and optimization of land use efficiency could spare land for the conservation outside the farmland [93,94], in line with the commonly advocated land use strategy of land sparing [51,95]. Practically, however, and based on our results, such arguments may not always be feasible. For instance, for the coffee investors landscape, our result showed that biodiversity was not an ES of interest in that landscape. At the same time, only stakeholders from the local scale had an interest in biodiversity in the cash crops and food first landscapes. This could indicate that practically the increased return from agricultural investment could further exacerbate biodiversity loss in many ways. The increasing use of farm agrochemicals, for example, often contributes to the eradication of farmland biodiversity [96], and agricultural land expansion into forest causes the loss of genetic diversity [97,98] and reduces carbon storage [99].

Here, too, a shift towards the biosphere reserve could focus on balancing ES production and biodiversity. Indeed, our results show that biodiversity is an ES of key interest for stakeholders at all governance levels in the biosphere reserve landscape, and the landscape features multi-functional land use involving protected areas as well as agricultural land [92]. Such multi-functional landscapes are characterized by a diverse set of ES, which often can be accessed by a diverse set of stakeholders [35], and leads to reduced tradeoffs in the ES generated [34], and relatively high levels of biodiversity [100].

Bringing power and governance into participatory scenario planning

Our exploration of stakeholder constellations, interests, and influences in plausible future landscapes adds a new layer of information to the narrative descriptions of scenarios. These additional insights will help decision makers to better judge which scenarios they prefer and deal with potential future governance and power relation issues. The more specific incorporation of such social and governance dimensions in the scenario narrative of landscapes can provide multiple opportunities for proactive and sustainable landscape management. First, it enriches knowledge about the future landscape in terms of its social and ecological properties and should be used as input to make well-informed landscape decisions [101]. Second, it enables the identification of divergent landscape aspirations and the harmonization of potential conflicts arising from multi-level stakeholder interactions within future landscapes [102]. Third, it enables identifying key stakeholders in the transitioning towards a desirable future land use scenario, or better understanding which stakeholders might be marginalized under different plausible scenarios. Finally, it informs the institutional and spatial scale to intervene to achieve a desired future landscape [13,38].

In addition to the empirical findings discussed above, the research presented here provides an innovative methodological approach that addresses the governance dimensions of changing landscapes both spatially and temporally. Specifically, we combined the notion of space-for-time substitution, scenario planning, and multi-level stakeholder analysis to further advance landscape-level social-ecological scenarios. The use of space-for-time substitution to study social aspects of changing landscapes is a novel contribution, especially for assessing the governance implications of landscape change [55,56,58]. Furthermore, in the absence of methods that precisely predict future landscapes, the use of proxy landscapes can be a feasible solution for gauging and analysing future changes in a given focal landscape.

Conclusion

We studied proxy landscapes and demonstrated how multi-level stakeholder constellations, interests, and influence on ES may change in future landscapes in southwestern Ethiopia. From an empirical point of view, we showed that changes in the landscape bring different stakeholders, divergent interests, and influences on ES generated from future landscapes. Based on our work, we conclude that: first, for sustainable future landscape management, in addition to the biophysical changes, accounting for the social and governance dimensions is important to make informed and proactive decisions. Second, future landscapes imply divergent stakeholder aspirations, both from the proximate and remote stakeholders. Therefore future landscape management should account for the diversity in stakeholder interests and multi-level stakeholder dynamics. For instance, this could be facilitated by participatory landscape management approaches that enable stakeholder plurality in the future landscape visioning exercise; and consideration of regional and global dynamics in landscape management planning and intervention. Finally, from a methodological perspective, the novel approach we presented in this study–integrating space–for–time substitution, scenario planning, and multilevel stakeholder analysis–provides useful pointers for further studies elsewhere. Indeed, our study could be used as a methodological benchmark or template for how to apply space-for-time substitution when studying change in social-ecological systems.

Supporting information

S1 Text. Table A: Key social and land-use features of the focal and proxy landscapes. Table B: List of stakeholders interested and influences ecosystem services generated from the focal and proxy landscapes. Table C: Description of Stakeholders Groups.
(PDF)

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