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SPECIAL FEATURE: ORIGINAL ARTICLE

Leverage Points for Sustainability Transformations

A leverage points perspective on institutions for food security in a smallholder-dominated landscape in southwestern Ethiopia

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Abstract

Despite concerted efforts, achieving the goal of universal food security remains challenging. Food security interventions occur at different levels of systemic depth. Some interventions target visible supply-side gaps, while others focus on deeper systemic problems in the food system. Here, we used a leverage points perspective to ask how multiple types of more superficial (shallow) and more fundamental (deep) interventions in the food system interact. Focusing on a case study in southwestern Ethiopia, we examined (1) recent changes in formal and informal institutions related to food security; (2) the effects of formal and informal institutions on the food system at different levels of systemic depth (i.e., on parameters, feedbacks, design, and intent); and (3) issues of institutional interplay between formal and informal institutions. We surveyed 150 rural households and analyzed key policy documents. Both formal and informal institutions were perceived to improve food security. However, at the intent level, formal institutions primarily aimed to enhance food supply, while informal institutions additionally sought to build trust among farmers. At the design level, formal interventions targeted information flow through a newly created agricultural extension system, while informal institutions facilitated labor sharing and communication. In terms of institutional interplay, new formal institutions had partly undermined pre-existing informal institutions. We conclude that both visible supply-side gaps and deeper drivers of food insecurity should be targeted through food security interventions. Interventions need to be cognizant of potentially unexpected ways of institutional interplay, especially between formal and informal institutions.

Keywords Food security · Formal institutions · Informal institutions · Leverage points · Sustainability

Introduction

Food insecurity is one of the most pressing contemporary problems, particularly for countries in the global south (FAO 2019). "Food security is achieved when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for a healthy and active life" (World Food Summit 1996). Despite concerted efforts from the global community, for instance the 2030 Sustainable Development Goals (United Nation 2015) and Agenda 2063 of the African Union (African Union Commission 2015), food insecurity remains a major sustainability challenge. Globally, the number of food insecure people has been consistently increasing since 2014, and currently 750 million people—or nearly one in ten people in the world—are considered severely food insecure (FAO 2020). This is often attributed to biophysical factors such as resource degradation (McLaughlin and Kinzelbach

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2015) and climate change (Ehrlich and Ehrlich 2013), as well as poor governance of equitable food distribution (McKeon 2014), unbalanced power relations between global and local actors (McKeon 2014; Vos 2015), and human population growth (Vos 2015).

Interventions to address food insecurity are guided by the underlying problem framing (Jiren et al. 2020). Two starkly contrasting framings exist at the science–policy interface: a conventional framing following on from a green revolution discourse, and an alternative framing around food sovereignty. The conventional framing primarily focuses on increasing food production through agricultural intensification (Shaw 2007; Shiva 2011). This framing often translates into interventions that seek to optimize efficiency in agricultural production, and targets the supply-side constraint of food insecurity—it is a framing that is dominant in many parts of the global south, especially in Africa (Africa Development Bank 2014). This framing, however, pays minimal attention to other, sometimes underlying causes of food insecurity such as institutional interplay or power imbalances—i.e., it only focuses on food availability, while other dimensions of food security, such as access or dietary diversity, are glossed over (Wittman 2011; Holt-Giménez and Altieri 2012). Despite rich scholarly evidence showing that a primary focus on agricultural efficiency optimization on its own does not change the dynamics ultimately causing food insecurity (Sen 1992, 1981; McKeon 2014), this type of framing remains dominant in numerous countries of the global south (Africa Development Bank 2014; Jiren et al. 2020).

In response, the food sovereignty discourse seeks to address deeper systemic problems of food insecurity, for instance through focusing on actors, institutions and power relations within the food system (Patel 2009; Leventon and Laudan 2017), including recognition of social organizations and informal institutions (Nyleni 2007; La Via Campesina 2014). This framing prioritizes the empowerment of local people, cultures and institutions, focuses on interventions that seek to reduce local vulnerability to shocks, and pays attention to the rights of smallholders to have greater control in the food system (Schanbacher 2010; Clapp 2015; McKeon 2014). With its emphasis on local rights, one possible challenge for a food sovereignty framing is its limited concern for the question how to meet rapidly rising international demand for food (Shilomboleni 2017).

Ultimately, both food supply-side challenges as well as deeper systemic problems around access to food can be important in different instances. Yet, identifying how to intervene in a given food system to most effectively improve food security remains challenging in practice. Addressing food insecurity is not a matter of finding the single best silver-bullet intervention, but relies on harmonizing many different interventions, including across national and sub-national levels, as well as between formal and informal institutions. Uncovering how different interventions and their interplay have influenced food security in particular case studies is critical to learn where best to intervene in the future, and how to harmonize interventions across different levels of governance. To enable such an analysis, in this paper, we use a *leverage points perspective* (Fischer and Riechers 2019) to analyze different types and levels of interventions, and interactions between these interventions, in a food system in southwestern Ethiopia.

Leverage points are places to intervene in a system (Meadows 1999). Meadows (1999) identified a hierarchy of twelve places to intervene, which ranged from leverage points where interventions are easy to implement but have limited potential to transform the system—i.e., *shallow leverage points* (Abson et al. 2017)—to leverage points in which interventions are more systemic and, therefore, can bring about transformative change—*deep leverage points* (Abson et al. 2017). In the context of food systems, shallow leverage points denote interventions that primarily target visible gaps in the system, especially on the supply side. These interventions might be relatively straightforward or technical in nature, but arguably, may be unable to change the systemic structures that underpin food insecurity at deeper levels. By contrast, deep leverage points are interventions that systematically address underlying problems of food insecurity, including self-reinforcing impediments to universal access to food. Interventions at deep leverage points are more difficult to implement but, in turn, have the potential to bring about transformative change.

Abson et al. (2017) clustered leverage points into four system characteristics according to their level of depth: Shallow leverage points are characteristics such as (i) *parameters* and (ii) *feedbacks*. Shallow leverage points might focus on increasing food production via better technologies. Deeper leverage points cover the (iii) *design* and (iv) *intent* of a system and might focus, for example, on institutional interplay and power relations in the governance of food security. Finally, a leverage points perspective also helps to conceptualize interactions among multiple interventions (Fischer and Riechers 2019; Manlosa et al. 2019)—for example, an intervention at the parameter level could constrain or alternatively facilitate changes in system design or intent (Manlosa et al. 2019).

To date, few studies have systematically analyzed how interventions at different levels of systemic depth, including both formal and informal institutions, in the food system interact and influence food security outcomes. This is a significant research gap—for example, new formal institutional interventions can bolster the efforts already pursued through informal institutions (Meijerink et al. 2014), or alternatively, can undermine existing efforts (Helmke and Levitsky 2004; van de Walle 2012).

We applied the leverage points perspective to a food system in southwestern Ethiopia. Ethiopia provides a highly relevant context for this work because the country is highly food insecure, with two in five people nutritionally food insecure, and 30% of the population living below the poverty line (CSA/WFP 2014). Multiple, partly competing approaches to improve food security are currently being pursued by the government (Jiren et al. 2020), while at the same time, more than half of the population is involved in different types of informal institutions—mainly informal financial transaction and labor sharing institutions—related to food security (Aredo 1993; Negera et al. 2019).

With this study, we specifically aimed to: (1) provide an overview of current changes in formal and informal institutions with respect to the two contrasting framings of food security, namely framing around the green revolution versus food sovereignty discourses; (2) analyze the levels of systemic depth (i.e., parameters, feedbacks, design, and intent) of interventions targeted by formal and informal institutions and their effects on the food system, and (3) uncover possible interactions between informal and formal institutions (i.e., institutional interplay, Leventon and Laudan 2017). We defined institutions as established systems, prevalent social rules and organized practices that structure social interactions, which can be presented formally or informally (Hodgson 2006; March and Olsen 2009). In this paper, we understand formal institutions as existing government policies, strategies and officially established ways of collaborating across multiple government bodies in Ethiopia. By informal institutions, we refer to any practices and ways of structuring collaborations that are culturally embedded within communities, without being regulated in writing or officially enforced.

Methods

Study area

The structure of the government in Ethiopia consists of five administrative levels: (1) federal/national, (2) regional (state), (3) zonal, (4) woreda (district), and (5) kebele (municipality). Our study was conducted in Jimma zone, Oromia regional state, southwestern Ethiopia. Jimma zone is located approximately 350 km southwest of Addis Ababa and is home to the Oromo ethnic group. Jimma zone has approximately 3 million inhabitants, of which nearly 90% live in rural areas, where subsistence farming is the main livelihood strategy (OBFED 2012). Smallholders in Jimma zone produce cereals — maize, teff, wheat, barley and sorghum—mainly for subsistence, and coffee (*Coffea arabica)* and khat (*Catha edulis)* as cash crops 2012). Most households also keep small numbers of livestock (cattle, sheep and poultry), mostly for domestic use. Forest-based ecosystem services are also highly relevant for local livelihoods (Ango et al. 2014). In terms of food security, although food insecure by international standard, people in Jimma zone are relatively better-off than people in many other parts of Ethiopia, for example in terms of agricultural production, dietary intakes, and levels of poverty (CSA/WFP 2014).

Within Jimma zone, we covered three woredas (Gumay, Gera, and Setema), with two kebeles in each (Kuda Kufi, Bera Werengo, Kela Hareri, Borcho Deka, Gido Bere, Difo Mani). The six kebeles represented diversity in terms of biophysical conditions, such as forest cover and altitude, as well as socio-economic conditions, such as proximity to markets and accessibility of social services. For example, in terms of altitude and forest cover, Kella Hareri and Borcho Deka consist of large forest areas, and people in these kebeles are predominantly engaged in the production of coffee. People in Bereha Werango and Gido Beri predominantly produce food crops including maize, sorghum, wheat and teff. Kuda Kufi and Difo Mani have relatively good access to road and market infrastructures in the nearby towns. Additional details on these kebeles are available in Manlosa et al. (2019).

Data collection and analysis

We used a mixed methods approach, involving qualitative and quantitative data, for this study: a structured survey provided insights into current changes in formal and informal institutions related to food security (aim 1), and on informal institutions within the food system (aim 2). The survey was used to collect quantitative data including on household food security, and qualitative data on trends and perceived reasons for changes in food security as well as informal institutions. Additionally, a policy document analysis was used to uncover the effects of formal institutions within the food system (aim 2). To uncover possible interactions between informal and formal institutions (aim 3), we used data from the structured household survey and policy documents.

Household survey on informal institutions

The quantitative survey targeted 150 randomly selected households across the six kebeles. Twenty-five households in each kebele—i.e., between 5 and 6 percent of households in each kebele were chosen randomly by targeting the roofs of houses as visible in remote sensing imagery. In line with the aim of our paper, we focused on capturing the participation in the informal institutions across a range of agro-ecological and socio-economic conditions. For this reason, instead of increasing the sample size per kebele by focusing on just two or three kebeles, we chose to work in six kebeles—but the trade-off was that we collected information from only five to six percent of possible respondents in each kebele. All

150 identified households participated in the survey because of prior experience with our research team (Manlosa et al. 2019). The survey included both closed questions (e.g., on household socio-economic and demographic conditions and food security; see Appendix 1) and open-ended questions (e.g., on reasons for food insecurity and to explain informal institutions, Appendix 1). Questions in the first two sections of the questionnaire (T1 and T2, Appendix 1) were designed primarily to collect data on household socio-economic characteristics; whereas, section three (T3, Appendix 1) was designed to obtain data on household food security. Item non-response was low and precise answer rates are given for each question in the results. The response rate for the study was > 95%.

To quantify household food security, we applied a modified version of the Household Food Insecurity Access Scale (HFIAS) (Coates et al. 2007; Maxwell et al. 2014). The HFIAS is a simple and widely used tool to collect data on household food security (Gebreyesus et al. 2015). In our modified version, we asked respondents five questions about the frequency with which they experienced different types of conditions indicating increasingly severe levels of food insecurity—from worrying about not having enough food up to going to bed hungry due to the absence of sufficient food for the household. Respondents were asked to recall the last lean season when answering these questions, which locally, is the most important season from a perspective of suffering food insecurity—the last lean season was 2–3 months ago at the time the survey was conducted (see T3, Appendix 1). Prior work in the study area successfully used a similar approach (Manlosa et al. 2019).

Respondents answered according to four classes of frequencies, namely as conditions they experienced never (never), rarely (once or twice per month), sometimes (three to ten times a month) or often (more than ten times per month). To calculate the modified HFIAS score, each question was given a score of zero (never), one (rarely), two (sometimes) or three (often), and the responses to all questions were summed up. Thus, a household with a total HFIAS score of 15 was highly food insecure, while the smallest score of zero indicated that the household was highly food secure.

Another focus of the survey (Appendix 1) was on three informal institutions including their current prevalence, trends in prevalence and effects on food security. For this study, we considered three locally important informal institutions: (1) Dado, a reciprocal labor sharing practice in food production activities commonly practiced during times of peak agricultural activity; (2) Dabo, a non-reciprocal general purpose labor sharing practice between community members; and (3) Diddaro, which describes consensus-based decision-making on prioritizing, growing and guarding crops in a coordinated way in neighboring fields in order to overcome the challenges of crop-raiding by wildlife. Many other informal institutions are also practiced to different degrees in southwestern Ethiopia. For example, Iddir is an informal insurance scheme where people in a given settlement areas pool resources to safeguard against unexpected risks, and Iqub is a periodic financial transaction which amounts to an alternative banking system (Negera et al. 2019). For this study, we focused on Diddaro, Dado and Dabo because, currently, these are the most dominant informal institutions practiced in the area. They also provide a good example where formal and informal institutions interact, and are directly related to food security.

The prevalence of informal institutions in the study area was ascertained by asking if the household had farmed fields on the basis of Diddaro over the last year (question 10, Appendix 1), and if the household was involved, and how frequently, in Dado or Dabo (T5, Appendix 1). Trends in prevalence and reasons for these trends were obtained through closed and open-ended questions, respectively.

For administering the survey, we first translated the questions into Afaan Oromo, and the results were translated back to English to assure no meaning had been lost. The questionnaire was pretested with 35 households in June 2018. After adjustments, such as re-wording HFIAS items to make them more understandable by the respondents, the household questionnaire was administered in October and November 2018. During data collection, informed voluntary consent was obtained from all participating households, and households were informed about the project and their freedom to withdraw from it at any time.

For our quantitative analysis, we calculated the HFIAS to determine current food security (aim 1). We then calculated the Spearman rank correlation between household HFIAS and participation in informal institutions (aim 2). Qualitative data from the open ended questions regarding the trends and perceived reasons for the changes in the conditions of food security and informal institutions were transcribed and coded using NVivo. Through subsequent coding with increasing level of abstraction, categories of formal institutional interventions that influenced the functioning of the three informal institutions (Diddaro, Dado and Dabo) were identified. After identifying which formal institutions influenced the functioning of informal institutions through the results of the policy analysis, we used the leverage points perspective as an analytical tool—that is, we coded the data, and classified and explained the consequences of institutional interplay in terms of their systemic depth (parameters, feedbacks, design and intent).

Policy document analysis for formal institutions

For the policy document analysis, we first identified the dominant food security and agricultural strategies

encapsulated in policy, strategy and planning documents. Because we intended to identify the main goals and major formal interventions related to food security, a detailed food security policy narrative and discourse analysis was not conducted (cf. Keeley and Scoones 2000; Järnberg et al. 2018; Jiren et al. 2020). We focused on the most important agricultural development policies, strategies and plans: the Rural Development Policy and Strategies (RDPS), which outlines key principles and strategies underlying Ethiopian agricultural and rural development (MoFED 2003); the Agricultural Development Led Industrialization (ADLI) document, which provides the overall development strategy and direction of the country (FDRE 1995); and the Growth and Transformation Plan (GTP-II), which outlines Ethiopia's five-year development plan for all development sectors including the agricultural sector (MoFED 2010). There are many policy documents that relate to food security in Ethiopia. For our study, we screened available policy documents and focused on the above mentioned documents because these outline the national strategies geared to address the issue of food security. We also consulted Ethiopia's agricultural sector policy and investment framework (PIF) (FDRE MoARD 2010), the Comprehensive Africa Agricultural Development Program (NEPAD 2003) and the Climate Resilient Green Economy (FDRE 2011) to provide additional background information for the analysis; but this latter set of documents was not analyzed in detail.

For the analysis of the effect of formal institutional interventions in the food system, we deductively created four broad categories in the software NVivo. Those categories were the systemic depth of *intent, design, feedback,* and *parameters*. From each of the three focal policy documents, we specifically coded statements stipulated in the policy documents related to the goal (the main goal stipulated in these documents); objectives (the strategic directions, for example if the strategy was framed under a green revolution versus a food sovereignty paradigm); structures (institutional mechanisms endorsed for achieving the desired policy goal, such as the structure of organizations involved); and strategies (implementation strategies, that is, tangible means to increase agricultural production and productivity). These data were coded, classified and explained according to the four system characteristics of the leverage points perceptive.

Results

Perception of local food insecurity

The majority of respondents were moderately food insecure, scoring a mean HFIAS of 9.7 ± 0.73 (mean ± standard error). The perception of the development of food security over the last ten years was divided: 51% ($n = 77$) of respondents reported increasing food security, 15% ($n = 23$) reported no change, and 34% ($n = 50$) perceived household food security had been declining.

Both increasing and decreasing food security were attributed to formal and informal institutions as well as other factors (Table 1). On one side of the spectrum, some interviewees reported that strengthened informal social networks and local cooperation as well as experiential learning, all partly facilitated by informal institutions, had improved food security in some cases. Other respondents perceived formal institutions such as the deployment of agricultural extension agents in each kebele, as well as the increased application of improved seeds, inorganic fertilizers and herbicides as main reasons for the improvement in food security. On the other side of the spectrum, respondents perceiving a decrease in food security stated land scarcity, a decline in land productivity, increased population and the deterioration of informal institutions as reasons for this decline.

Table 1 Perceived trends of household food security and perceived reasons for the trends ($n = 124$)

Perceived reasons	Perceived trends of food security	
	Decline	Improved
Formal institutions	Increased human-wildlife conflicts (hunting ban); Mandatory agricultural technologies increased cost & debt; Land tenure problems (e.g., inheritance of increasingly smaller parcels, no land market)	Access to Development Agents' services and modern farm technology; Access to production resources incl. labor and farmland through inheritance; Increased access to agricultural markets
Informal institutions	Decline in informal institutions: Dado, Dabo and share-cropping arrangement between landowners and landless people; Increased human–wildlife conflicts (decline in Diddaro)	Experiential co-learning; Strengthened social network and local cooperation among farmers; Diversification of crops
Other factors	Land scarcity and decline in agricultural productivity; Increased family sizes; Increased sickness of household members; Decline in farm income opportunities	Diversification of income sources from agriculture, petty trade and non-agricultural activities; Improved remittance

Effects of formal institutions on the food system

Formal and informal institutions influenced different system characteristics. Here, we show how these institutions differently influenced system intent, system design and the feedbacks and parameters within the food system.

System intent: enhancing agricultural productivity

Ethiopia's formal food security approach has primarily focused on enhancing agricultural productivity. Our policy document analysis indicated that the overall goal (intent of the system) of formal institutions was to increase smallholder agricultural productivity through agricultural commercialization (e.g., as stipulated in the GTP), transforming subsistence production to specialization and diversification (e.g., as stipulated in the RDPS) and linking smallholder agriculture to input and output markets (e.g., as stipulated in the ADLI) (Table 2). This formal institutional approach to improving food security was mainly framed under the discourse of the green revolution, whereby increasing the production of selected crops was considered as a key solution to solve the problem of food insecurity (Table 2).

System design: restructuring agricultural extension

At the design level, the most important formal institutional intervention was the restructuring of the agricultural extension system. A key development since the mid-1990s was that formal interventions in agriculture and food security were guided by the agricultural extension package program, and this development was considered central in all key policy documents. As a result of this, two principal structural changes were undertaken. First, agricultural extension packages and advisory services were provided by deploying a large number of trained development agents. At each kebele, three development agents with different expertise (crop production, livestock production and health, natural resource management) were deployed. These development agents serve to ensure increased agricultural production through effectively communicating agricultural technologies to farmers, providing agricultural advisory services to smallholders, and linking smallholders with technology developers, such as agricultural research centers and market agencies.

Second, each kebele was newly sub-divided into three sub-levels to further improve the effectiveness of development agents: *Got* or *zone* (200–300 adjacent households); *Gare* (50–100 adjacent households) and *Shane* (five neighboring households). These sub-divisions are locally collectively known as *development army,* and all sub-divisions have their own respective chairperson and executive committees that represent their respective sub-divisions in different development, conservation and political issues. They are also gatekeepers through which different sectors and programs reach the community. Development agents now mentor, provide agricultural advisory services, and monitor progress through these sub-kebele structures. From the perspective of ensuring food security, the objective here was to facilitate the timely flow of agricultural information to farmers, monitor and encourage the use of production enhancing

Table 2 Types of interventions, levels of intervention and their perceived trends over the last 10 years

Main institutions	Intended intervention to alleviate food security	System characteristic	Perceived trend in past 10 years
Formal institutions			
RDPS, ADLI, GTP	Increasing smallholder agricultural productivity	Intent	
RDPS, ADLI	Promoting and strengthening agricultural extension services	Design	Increasing
RDPS, ADLI	Deployment of trained development agents at kebele level	Design	Increasing
RDPS, ADLI, GTP,	Community restructuring to foster collective action (*got, gare* and *shane)*	Design	Increasing
RDPS, ADLI, GTP	Intensification practices, including use of fertilizer, pesticides and insecticides	Parameter	Increasing
GTP, ADLI	Commercialization and land use conversion into cash crops and perennials such as coffee	Parameter	Increasing
Informal institutions			
Diddaro, Dado, Dabo	Spirit of cooperation, trust and learning	Intent	Decreasing
Diddaro, Dado, Dabo	Strengthening social network and trust	Intent	Decreasing
Diddaro, Dado, Dabo	Utilization of local knowledge and experience sharing; a value of local norms and traditions	Intent	Decreasing
Diddaro	Labor sharing to overcome crop-raiding; democratic decision-making on choice of crops	Design	Decreasing/ Increasing
Dado	Labor sharing during peak periods	Design	Decreasing
Dabo	Labor sharing during for general purpose	Design	Decreasing

agricultural technologies such as improved seeds and fertilizer, and encourage collective action around labor sharing in agriculture (Table 2). Our findings from the household survey indicated that these design level changes were generally perceived as having had a positive influence on household food security.

System parameters: increased agrochemical use

Changes at parameter level encouraged by formal interventions with respect to food security included agricultural intensification, for example, through increasing the application of agrochemicals and fertilizer that directly targets increasing agricultural production (Table 2). Our policy document analysis showed that three key interventions had taken place. (1) Expansion of agricultural technologies including irrigation, inorganic fertilizer, and agrochemicals such as herbicides and pesticides were the main parameter-level changes for increasing agricultural production and productivity, which aimed to improve household food security. This intervention further included encouraging farmers to use improved seeds of commercial crops and high value cash crops rather than traditional varieties of subsistence crops. (2) Expansion of best agricultural practices such as row planting and commercial crop production which sought to double agricultural yields. (3) Improving the natural resource base, i.e., promoting soil and water conservation and watershed management as means to improve farm productivity. Those changes were mainly facilitated and monitored by interventions at the design level (see above), and emerged among the perceived reasons for the improvement in local food security (Table 1). The high cost of production enhancing technologies, and sometimes involuntary (i.e., forced) application of these technologies by smallholders, however, were perceived as reasons for the decline in household food security by some respondents.

Effects of informal institutions on the food system

Diddaro was the most widely practiced informal institution. Of the 150 respondents, 60% ($n=90$) indicated they were participating in Diddaro and 46% of 129 of respondents who responded ($n=59$) generally perceived Diddaro to be increasing over the last decade (Table S1). Among others, biophysical and demographic factors, such as increased cultivated land and a larger population, as well as the increased cost of agricultural intensification (through the cost of fertilizer, improved seeds and agrochemicals) were listed as contributing to the increase in household participation in Diddaro (Table S2). Diddaro mainly involved households who hold farmland adjacent to each other, such that they can coordinate their crop types and share labor, for example, to avoid crop-raiding by wildlife. Not all parcels of a given household's farmland are managed under Diddaro. Our results showed that 44% of total respondents' farmland was managed under Diddaro. The decision to join Diddaro was considered voluntary by our respondents.

Dado and Dabo were less widely used in the study area. Out of 150 respondents, 43% ($n=65$) indicated they were participating in Dado, while only 26% ($n=39$) currently participated in Dabo. Of 142 respondents who responded, 35% ($n=50$) perceived Dado to be declining over the last 10 years; and 34% ($n=48$) perceived Dabo to be declining over the last 10 years (Table S2). Participation in Dado and Dabo depended on the availability of land by households, household size, household labor availability, and the ease with which agricultural helpers could be recruited. Notably, despite declining participation in Dabo and Dado, participation in these informal institutions significantly influenced household food security. Households that more frequently participated in both Dado and Dabo were more food secure (Spearman's rho $=0.22$, $p<0.05$) than non-participating households.

System intent: building trust and social networks, maintaining experience and values

All three informal institutions concerned with food security were commonly used to bridge difficult periods as well as to pool resources, facilitate collective action, and thereby enhance agricultural production (Table S1). At the intent level, the aims of the three informal institutions (Diddaro, Dado and Dabo) converged around strengthening the social network and trust, utilization of local knowledge and experience, as well as maintaining local norms and traditions (Table S2). By means of increasing agricultural production and strengthening social cohesion, and by promoting trust among the members, the informal institutions sought to foster food security. The informal institutional approach to food security, thus, could be seen as matching discourses of food sovereignty. That is, similar to the tenets of food sovereignty, local informal institutions capitalized on people's experiences and values, valued local practices, norms and networks, and through this empowered them to improve their food secure even in difficult times (Table 2).

System design: labor sharing and enhancing communication

At the design level, Diddaro intervened through labor sharing and enhancing agricultural communication among local people, fostering collective action for protection of crops from wildlife, as well as encouraging democratic decision-making on the choice of crops. In this regard, the majority of respondents indicated that labor sharing and communication were key reasons for participation in Diddaro. Out

of the 90 households who participated in Diddaro, 90% ($n=81$) perceived that participation in Diddaro improved their food security, while 81% ($n=73$) indicated that a lack of local Diddaro could cause major problems to household food security. Similar to Diddaro, Dado and Dabo facilitated pooling labor for farming and other tasks such as construction of houses. These informal institutions also strengthened social cohesion, promoted communication and learning, and helped to maintain local practices, values and culture (Table S1).

The most notable effects of informal institutions, thus, were on intent and design, with feedbacks and parameters only indirectly affected. For example, household labor sharing in Dado and Dabo improved the timely sowing and harvesting of crops, and labor sharing in Diddaro reduced crop loss from wildlife crop-raiding.

Institutional interplay among formal and informal institutions

Our empirical results showed that our respondents considered formal interventions in the domains of design and parameters as reasons for the decline in the function of informal institutions. The decline in informal institutions was related to changes enforced by formal institutions because those partly contradicted the interventions and aims previously encouraged through informal institutions. For example, enforcement of the formal policy (design) that seeks to transform agriculture from subsistence farming to commercial crop production fostered the production of coffee, khat and eucalyptus, thereby driving land use conversion to cash crops (parameters). These changes, in turn, negatively affected collective, bottom-up agency as previously promoted by informal institutions. Further, the increased application of agricultural technologies (parameters) such as herbicides and insecticides were linked to reduced participation in Dado/Dabo because, for instance, herbicides replaced the labor requirement in agricultural activities (Table S2).

The most important reason for a decline of informal institutions in the study area was stated to be multiple types of structural change facilitated by the government (design). The newly created sub-kebele structural network, thus, coercively replaced the informal institutions Diddaro, Dado and Dabo in some cases, effectively undermining the social goals previously upheld through these informal institutions. Some respondents felt that this structural change was less effective to combat food insecurity than the traditional, informal institutions had been. This was both because the new formal arrangements followed, in contrast to Diddaro, household settlement instead of farmland adjacency, and also because some of the new structures had served political purposes such as spying on one another (Table S2). Moreover, participation in the new structures was involuntary, such that the new structures often undermined trust among local people (while informal institutions had helped to build trust). Notwithstanding the important role of formal institutions in causing changes in informal institutions, other (resource-related) factors, such as scarcity of land and oxen, and social factors such as increasing individualism were also mentioned as additional reasons for the decline of informal institutions.

Discussion

Our findings indicate that new formal institutions—through their particular intent, design and parameter-level interventions—partly contributed to improved food security in our study area. However, at the same time, they undermined the intent and design of pre-existing informal institutions; sometimes to the detriment of food security. A leverage points perspective, thus, was able to add nuance to existing discussions about formal versus informal institutions—showing how competing intents and designs in particular can be in conflict with one another. In the following, we discuss these findings with respect to the dimensions and places of intervention of institutions, and institutional interplay in food security.

Institutional interventions at different systemic levels in the food security

Our study highlighted the important contribution of both formal and informal institutions to household food security in southwestern Ethiopia. However, formal and informal interventions in food security varied in terms of the dimensions of food security targeted, including the underlying reasoning of why food insecurity exists, and the systemic level targeted by interventions.

The formal interventions identified here primarily targeted the availability dimension of food security, seeing the problem of food insecurity from the supply side, and hence focusing on how to produce more food to close existing yield gaps—formal interventions approached food security from an agricultural production lens (Shaw 2007; Vos 2015). Key features of formal interventions in the food system were that they sought solutions at the intent level through a focus on food availability; at the design level through the deployment of development agents who could help disseminate information related to higher-yielding agricultural production; and at the parameter level through enforcing the widespread uptake of modern agricultural practices (Table 2). These interventions largely fit within a green revolution discourse (Shiva 2011), and are aligned with current food security policy in many developing countries—for example, more than half of all African countries (NEPAD 2003) emphasize

modernizing practices as a means of addressing food insecurity (Kidane and Worth 2012).

The structural changes (design) induced by formal institutions may increase agricultural production, and thereby improve food availability, for example, by encouraging the use of agricultural technology and applying fertilizer (parametric level) (Table 1). These interventions essentially seek to improve production efficiency. While this might be useful and even important in some instances, such interventions only target supply-side constraints in the food system, with limited influence on the overall food system. For instance, land tenure insecurity was one of the main factors mentioned by local people to negatively influence household food security, but this and other, similarly structural problems were not accounted for in the formal interventions (Table 1).

Experience from around the world indicates that interventions that equate increasing agricultural production with improving food security not only lead to overly simplistic policy prescriptions (Sen 1992, 1981; Shaw 2007), but could also cause unintended problems. For instance, the sole focus on food availability could result in social inequality, especially in smallholder-dominated landscapes such as the one we studied, where security over production resources is low (Table 1; Shaw 2007), where specialization practices can limit dietary diversity (Dillon et al. 2015) and foster community conflicts (Shiva 2011), as well as often resulting in biodiversity loss and pollution (Mooney and Hunt 2009). Focusing solely on increasing agricultural production also may be simply incompatible with local conditions. In southwestern Ethiopia, the high cost of agricultural modernization is incompatible with local preferences and capacities—i.e., most farmers cannot afford to purchase agricultural inputs such as fertilizer and agrochemicals (Table 1) (Meinzen-Dick 2007; Ingram 2011). Similar to our findings, previous studies in different parts of Ethiopia also highlighted that the strong focus on agricultural intensification was incompatible with local peoples' preferences (Jiren et al. 2018; Bergsten et al 2019; Leta 2019).

Thus, the formal interventions we observed in southwestern Ethiopia are rooted in an intent of "productivity", which is incomplete—and flowing from this, interventions at the design and parameter level that follow from this intent will have limited potential to truly transform the food system (Abson et al. 2017; Fischer and Riechers 2019; Dorninger et al. 2020). Important root causes of food insecurity such as distributional and procedural injustice, unequal power relations among different groups, and cultural and nutritional adequacy of food remain overlooked (Hodbod and Eakin 2015; McKeon 2014; Jiren et al. 2020). To bring about transformative change in the food system, formal institutional interventions, thus, needs to take a broader perspective of food insecurity and also examine some of the deeper, underlying challenges.

In contrast to formal institutions, long-standing informal institutions were embedded within local communities, values, and practices, and targeted diverse dimensions of food security including equity, dietary diversity, environmental adequacy and temporal stability (Wittman et al. 2017). At a deep level, the intent of informal institutions, thus, encapsulated a much more comprehensive understanding of the food system than was the case for formal institutions. For example, informal institutions sought to enhance social capital including sustaining social networks, promoting collective action, utilizing local knowledge and resources, fostering learning and building trust, and enabling local people to define their agricultural and food system (Table 2). Our findings from the three informal institutions, Diddaro, Dado and Dabo, indicated that at the design level, these informal institutions serve to facilitate collective action and communication, foster local people's participation and democratic decision-making, as well as labor sharing not only for the sake of increasing agricultural production, but also to maintain social capital extending to non-agricultural activities (e.g., Dabo). Collectively, key features of informal interventions identified in our study, thus, correspond to key pillars of food sovereignty rather than just the more narrow concept of food security (Nyleni 2007; Patel 2009; Leventon and Laudan 2017).

Given their social embeddedness, holistic nature of intervention, and focus on underlying problems of food security, informal institutional interventions are critical for food security in many countries of the global south (Fafchamps 2002; Bigsten 2006). In Sub-Saharan African countries, access to informal institutions and their benefits is often straightforward (Negera et al. 2019), and informal institutions build on local capacities and holistic realities of local people's livelihoods (Casson et al 2010). Informal institutions thereby mobilize important, actually available factors of production, such as labor sharing, and help to facilitate equitable and sustainable access to food—key issues that are often overlooked by formal institutions (Rodrik 2008; Casson et al. 2010).

Despite their many advantages, informal institutions are not a panacea to solve all problems of food insecurity. In the worst case, deeply embedded informal ways of organizing food systems can, for example, discourage adoption of new agricultural technologies (Jiren et al. 2018). As such, it appears that both formal and informal institutions can be useful to improve food security. However, transformative and equitable change towards universal food security seems unlikely without paying close attention to the many interrelated facets of food insecurity that go beyond a focus solely on food production.

Interlinked leverage points: institutional interplay

Formal and informal institutions, thus, made different contributions to food security, differed in their intent, and following from that, led to different concrete interventions at the design and parameter levels. Multiple interventions can interact in numerous ways, both at the same level of systemic depth (e.g., competing intents or designs), or across multiple levels of systemic depth (e.g., the formal design interventions may run counter to the intent of informal institutions). Multiple, co-occurring interventions can sometimes have surprising consequences for food security (Williamson and Kerekes 2011; Berkhout et al. 2018). Some studies found complementarity of multiple formal and informal interventions. For instance, an increase in local trust (a foundational system characteristic) created by informal labor sharing (an informal institution) enhanced participation in and effectiveness of the formal market system (a formal institution) in China (Tu and Bulte 2010). Such complementarity of different institutions in food security could be useful to simultaneously address multiple dimensions of food security (e.g., availability, access, stability, utilization), and to minimize the potential conflict leading to undesired outcome in the food security.

Contrary to this, our finding illuminated how formal interventions may undermine equally valuable informal interventions. Indeed, formal interventions in system design and parameters (such as kebele sub-division or agricultural modernization programs) could, over time, erode the intent and design levels of informal institutions, thereby increasingly narrowing efforts to address food security to the production dimension (Table 2). Similar problems have been observed in other contexts in Ethiopia. For example, Meijerink et al. (2014) found that the formal intervention of establishing the Ethiopian Commodity Exchange (design) in the agricultural market with the intent of maximizing market efficiency eroded trust among local participants and ultimately led to a decrease in their incomes. In the worst case, such interplay between formal and informal institutions, thus, can inadvertently expose farmers to multiple new problems (in addition to low agricultural yields), including a loss of rights over their agricultural systems, erosion of social networks, reduced social security, and loss of sustainable food self-sufficiency. Empirical studies elsewhere, for example in Ghana (van de Walle 2012), have indicated that a transition from subsistence to commercial crop production forced by formal public policy eroded long-established informal institutions, which consequently negatively influenced food security. Thus, while the presence of formal and informal institutions are both potentially useful to enhance food security, careful attention should be given to where such interventions occur, and how multiple coexisting institutions interact. A leverage points perspective suggests that clashes at the levels of system intent and design, in particular, are likely to lead to undesirable consequences because they pull local people in different, conflicting directions.

Conclusion

Deploying the concept of leverage points to explore how institutional interventions at different levels of systemic depth in the food system interact and influence food security outcomes, we illustrated in our study that both formal and informal institution could potentially contribute to improved food security. However, existing formal institutions were framed under the global green revolution discourse targeting food production in particular, whereas informal institutions more closely mirrored a food sovereignty discourse addressing multiple underlying social challenges potentially causing food insecurity. While the coexistence of both formal and informal institutions can help to cover multiple dimensions of food security, issues of the systemic level of intervention and complementarity between different interventions need careful attention. Notably, all institutions influence efforts to improve food security at different levels of systemic depth, such as the intent, design, and parameter levels. However, in our accounts of institutional interplay, formal institutions through their different intent and design undermined pre-existing informal institutions. We suggest that formal public policies should better recognize and uphold locally embedded informal institutions where these pursue socially desirable functions. Informal institutions, in turn, need to be flexible enough to accommodate change, including the modernization of farming practices in some instances. The fit between formal and informal institutions could be improved through establishment of governance structures, processes, and institutions that support stakeholder participation in policy making and implementation. This, in turn, could help to foster the compatibility of formal institutions with local dynamics, improve synergies with informal institutions, and widen the scope of interventions from the supply side to a more holistic focus in an effort to more effectively eradicate food insecurity.

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