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The influence of multilevel innovation platforms on continuing utilisation of smallholders' livestock feeding practices

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Abstract

Agricultural research for development (AR4D) agencies in sub-Saharan Africa (SSA) have increasingly turned to innovation platforms to enhance the impact of smallholder initiatives beyond program completion. Linking community-level IPs with IPs established at higher levels has been suggested as a strategy for addressing institutional barriers through linking actions across levels to create a conducive environment for innovation and achieve durable impacts. This research aims to understand the activities, actions or arrangements that were mediated by a multilevel set of IPs to sustain the use of livestock feeding practices in the Ethiopian Highlands. Two years after the multilevel IPs had been phased out data was collected to ascertain if innovation outcomes had been sustained. The study identified specific IP activities, actions and arrangements that constrained or enabled sustained use of the livestock innovations. The multilevel IPs and their activities were able to enhance technical changes around feed innovations that initiated a transition towards a sustainable feed system. Results showed that the sustained use of livestock feed innovation outcomes achieved depends on different factors and varied largely depending on how the feed innovations were tailored to the farmers' production objectives. Positive outcomes were identified for commercial-oriented farmers, especially where the feed innovations had been tailored to specific enterprises based on their needs for enhanced productivity, such as improved dairy farming. Conversely, for the majority of the subsistence-oriented farmers sustained use of some technical innovations was constrained by inadequate consideration of the subsistence farmers' immerging needs where there was uncertain access to forage seeds and affordable interlinked input services (breeding, financial, and veterinary). The study further discussed how livestock feed system transition enabled in case of commercially-oriented farmers and constrained in case of subsistence-oriented farmers and put a way forward in terms of mechanisms and strategies to inform similar future interventions that facilitate a context-specific combination of technological, organisational and institutional innovations necessary to make a difference. Finally, the study suggested a future research area could focus on understanding the role of multilevel IPs in dealing with multiple-scale demands across different sectors (such as cop-livestock-tree mixed farming systems) with strategies focusing on a specific theme (such as livestock value chain).

Introduction

Agricultural research for development (AR4D) agencies in Sub-Saharan Africa (SSA) have increasingly turned to innovation platforms to enhance the impact of smallholder initiatives beyond program completion. Homann-Kee Tui et al. (2013) define Innovation Platforms (IPs) as “spaces for learning, action and change where groups of individuals (who often represent organisations) with different backgrounds, expertise and interests come together to diagnose problems, identify opportunities and find ways to achieve their goals”. IPs can be established at single or multiple levels and are designed to foster innovation through deliberate facilitation of interactions among various stakeholders – farmers, traders, food processors, researchers, and government officials – who often depend on each other (Hall et al., 2006; Nederlof et al., 2011).

The premise that IPs can enhance and sustain the impact of agricultural innovations relates to facilitation of a demand-driven and system-oriented approach to tailoring innovation to specific needs of farmers (Schut et al., 2016). Hounkonnou et al. (2012) indicated that in addition to technological innovations, institutional changes are necessary conditions to bring about sustained improvements in agriculture in SSA and identified IPs as a promising innovation systems approach to achieve such changes. They state that “…smallholders themselves have insufficient power to change rules, norms, procedures, and laws, and to ‘pull down’ the provision of interlinked services and access to value chains – in brief, the institutions – that determine their opportunities” (p. 76).

At times, IPs are established at a single level and focus on addressing farm-level technical problems; therefore, their focus on the interlinked institutional changes required beyond the farm level to create opportunities for sustaining and scaling farm-level innovations is limited (Hall et al., 2016). The lack of focus on the institutional aspects of innovation has been traced mainly to the limited involvement of higher-level policymakers and value chain actors in IPs and poor alignment of IP activities with other relevant public or private initiatives (Lamers et al., 2017; Totin et al., 2020). The use of a multilevel system of IPs has been recognised as a positive step towards system-oriented approach to engaging higher-level decision-makers and other relevant actors (Nederlof et al., 2011; Schut et al., 2016), and linking actions across levels (Tucker et al., 2013). Such structures (hereafter referred to as 'multilevel IPs') involve the IPs that are established at the farmers’ level being linked with the IPs created at higher levels (district and national), where a more strategic focus can be achieved (Lema et al., 2021). Through their ability to connect various actors with different skills and competencies from across different levels, multilevel IPs have the potential to engage with the multiple actions required to address the interlinked barriers to innovation and bring both technical and system-level change (Kilelu et al., 2013; Lamers et al., 2017).

Often IPs are implemented through donor-supported projects operating according to short-term program cycles. Once the facilitated interactions and input support provided through the IPs, which might serve as incentives to adopt technologies, are withdrawn, there are critical challenges in scaling out the innovations beyond the intervention sites or even sustaining the innovations within the intervention sites. Most studies of IP effectiveness are primarily undertaken during the project lifetime and have thus concentrated on analysing how the innovation processes and facilitation occurring within the IPs foster technological and institutional innovations within this lifetime (Ayele et al., 2012; Davies et al., 2018; Hounkonnou et al., 2018; Kilelu et al., 2013). This raises an interesting question about farmers' continued use of innovations after the support and facilitation provided through the IPs has ceased. For example, a post-intervention impact study in Ghana and Benin identified that technological and institutional innovations that depend on artificial conditions created by short-term research project support are likely to be discontinued once a project has ceased (Sterk et al., 2013). Thus, post-intervention impact studies are important to understand whether and how the innovations achieved specifically through multilevel IPs have been sustained during the post-intervention period.

To understand the activities of a multilevel IP on enabling or constraining farmers' sustained use of livestock innovations a case study of the Africa RISING Ethiopian Highlands Phase I Project, which established multilevel IPs and was active from 2011 to 2016, was chosen. The research has two aims: (a) to develop an in-depth understanding of the activities, actions or arrangements that affect the sustained use of innovations after the multilevel IP was phased out, and (b) to examine how the multilevel IP structure influenced those activities, actions or arrangements beyond the active phase of the IPs. By identifying the key enabling and constraining activities, actions or arrangements, this paper seeks to reflect on past experiences to optimise the outcomes of IPs in the future towards sustaining impacts that last beyond the initial short-term project period.

Conceptual Framework

Approaches to agricultural innovation have progressively co-evolved from the linear transfer of technology approach towards an inclusive and system-oriented approach (For an overview see Klerkx et al., 2012). These approaches vary according to the actor's understanding of how innovations emerge and who plays what role in this process. The linear approach, which remains the dominant approach in SSA largely focuses on farm-level technical components of innovations (Hounkonnou et al., 2012). It considers the generation of technologies, transfer and utilisation as three separate activities performed by three groups of actors where technologies are generated by researchers and transferred to farmers through extension agents (Chambers and Jiggins, 1987). Acknowledgement that many actors play an active role in agricultural innovation, and that innovation processes are dynamic and complex has led scholars to progressively develop more inclusive and system-oriented approaches to innovation (Klerkx et al., 2012).

To understand and facilitate agricultural innovation the concept of Agricultural Innovation System (AIS) has gained currency as an inclusive and system-oriented approach to innovation (Hounkonnou et al., 2012). AIS is defined as "a network of organisations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organisation into economic use, together with the institutions and policies that affect the way different agents interact, share, access, exchange and use knowledge" (Hall et al., 2006: vi-vii). AIS has shifted the focus from "technology" to "innovation" and included not only farm-level technological components but also above farm-level organisational and institutional components that are critical for situating the innovations into economic use. According to Leeuwis and Van den Ban (2004), the technological component of innovation refers to new "hardware" such as farm-level technical components including fertiliser, seed, and planter, whereas organisational component or "orgware" refers to new ways of organising groups, production and/or consumption and finally institutional components or "software" refers to new or revised institutional set-ups, partnerships and policies.

The AIS concept emphasises the need to foster conducive innovation environments where researchers, policymakers, producers, end-users and entrepreneurs can mobilise their collective knowledge towards effective innovation. To facilitate such arrangements in pursuit of operationalising the concept of AIS, IPs have been widely applied as tools to foster interactions between actors to jointly solve interlinked agricultural problems from a system perspective (Klerkx et al., 2012). IPs have been conceptualised as intermediate structures that fulfil a set of functions to bring system-level changes that enable farmers to benefit from innovation and transition towards an improved system (Hounkonnou et al., 2018; Kilelu et al., 2013; Lema et al., 2021). Through engaging a diverse set of actors, fostering linkages and cooperation, and stimulating learning and mobilising resources, IPs aim to foster complementary technological, organisational and institutional innovations (Schut et al., 2016).

In fostering such a mix of innovations across multiple levels the use of multi-level IPs has been found to be promising. Multilevel IPs enable relevant actors including higher-level decision-makers, farmers and other local actors to closely work together in experimenting with socio-technical and institutional innovations, and thereby generate local evidence that can be used to negotiate for institutional and policy change (Nederlof et al., 2011). These innovations can occur at the farm level as well as across different administrative levels and are shaped through facilitated processes that embrace reflexive learning and adaptive management (Kilelu et al., 2013).

Evidence shows that IPs can progressively adapt and tailor innovation to the specific socio-economic, biophysical and institutional context of smallholders (Hounkonnou et al., 2018). The outcomes that IPs can achieve are not easily predicted (Hounkonnou et al., 2018) and they may not quickly adapt to emerging issues as this is also affected by different factors outside IPs (Kilelu et al., 2013). Thus, IP activities that strengthen feedback and learning to adapt and shape the direction of the innovation to emerging issues are important for enhancing the performance of IPs towards achieving tangible innovation outcomes that might be sustained beyond the project period.

Based on the above definitions and concepts of AIS, innovation and IPs we have drawn a conceptual framework (Figure 1) to understand how IPs foster different components of innovations during their operation and their effect on the sustained use of innovation beyond their lifetime. IPs facilitate change from System A (before IPs) to System B (during IPs in operation where farmers receive support to test and adopt new practices). System C refers to post-intervention where farmers may (dis)continue the use of innovations they adopted during the support provided through the IPs.

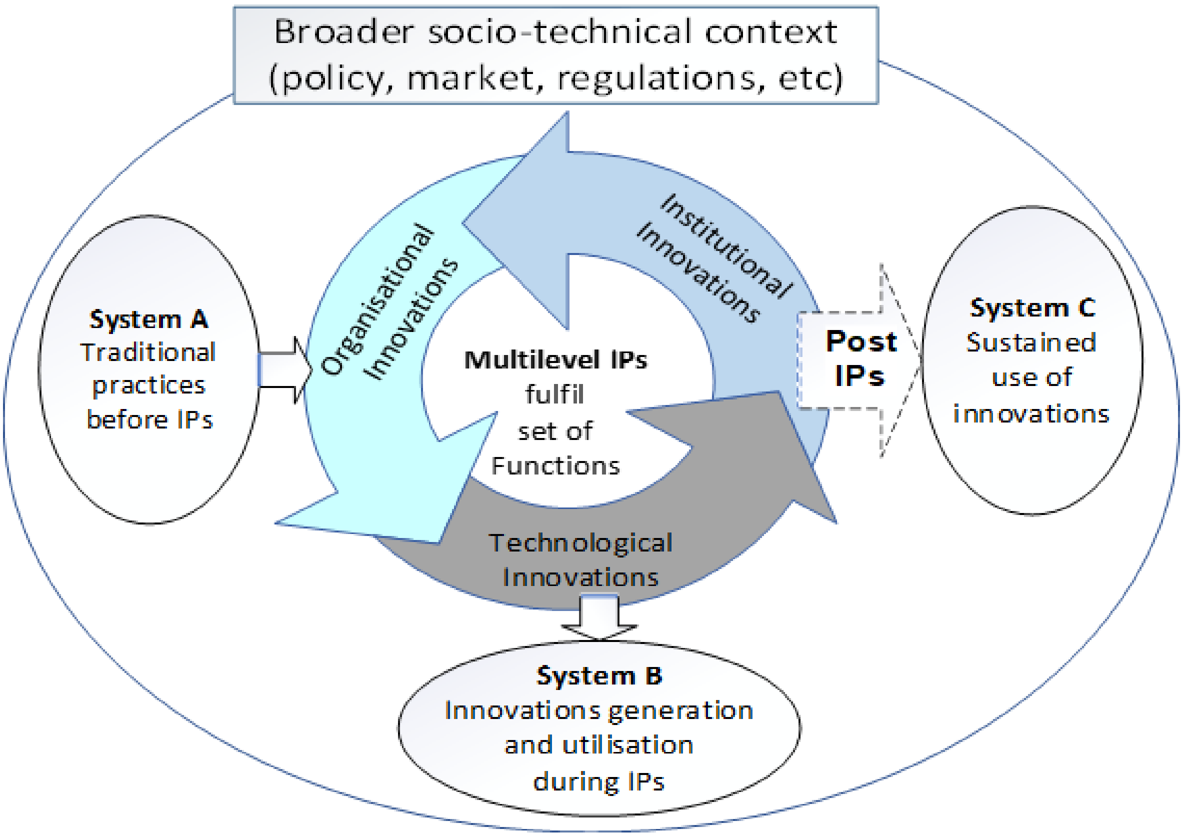

Figure 1. Conceptual framework – own elaboration based on (Hall et al., 2006; Leeuwis and Van den Ban, 2004; Nederlof et al., 2011).

Case study background and research design

Case study background

Africa RISING and its multilevel IPs

First phase of Africa RISING (Ethiopia) was a project of the International Livestock Research Institute (ILRI) that aimed to address the complex challenges experienced by crop-livestock farmers in the Ethiopian Highlands in the efficient management of their farm resources and dealing with institutional factors that cut across value chains. The project background and the multilevel IP composition are fully described in Lema et al. (2021). The project had two phases. During the first phase (2011–2016), the project identified, adapted, validated, and deployed innovative farming technologies for sustainable intensification in four regions of Ethiopia. In its second phase (2016–2021), the project aimed to scale out the innovations validated in Phase I. During its first phase of operation, Africa RISING established multilevel IPs to facilitate the integration and coordination of efforts of various partners across three administrative levels.

The administrative levels were informed by the Ethiopian administrative government structure: national (federal), woreda (district), and kebele (lowest administrative unit equivalent to the neighbourhood) (Figure 2).

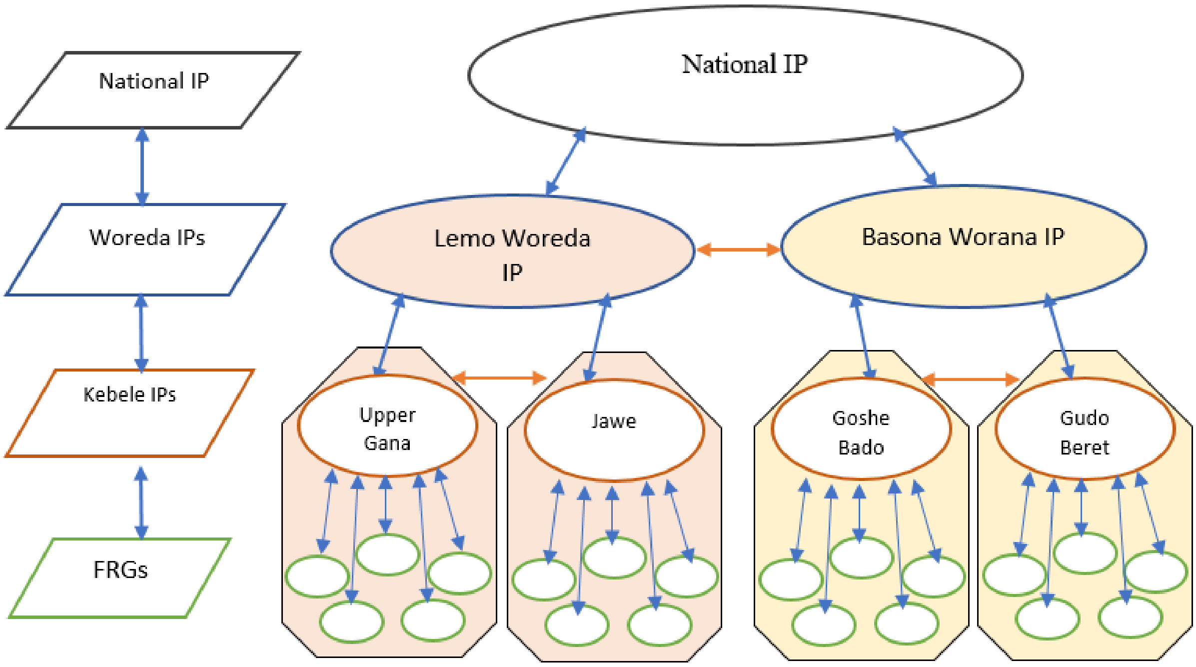

Figure 2: Schematic presentation of the multilevel IPs studied
It illustrates levels, vertical and horizontal linkages, and information flows between and across levels as indicated by the arrows (FRGs – Farmers Research Groups) (Lema et al., 2021).

The IPs are interlinked through representatives to exchange knowledge and information across levels during key learning events such as regular IP meetings, field days, and exchange visits. The lowest level of the multilevel IP structure was the FRGs where each FRG such as “tree lucerne FRG” comprised farmers who had similar issues/needs and tested one specific new technology on their farms and demonstrated these to other farmers. Kebele level IPs include men and women farmers representing each FRG and government department representatives including kebele administrators, livestock and crop development agents (DAs). DAs are frontline public extension workers in the kebeles who are assigned to promote the adoption of improved agricultural practices and inputs and provide close technical support to farmers. Kebele IPs were established to technically support and facilitate knowledge sharing and scaling among and beyond FRGs. Each of the two woredas’ administrative centres shared the same capital towns with that of the encompassing zone, offering a unique opportunity for the woreda-level IPs to engage diverse actors representing key government organisations at the zone level, including regional universities, regional research centres, NGOs, and agricultural offices such as crop, livestock, water and other sectors. The national IP members were mainly representatives of the research partners mainly CGIAR[1] centres that were leading the implementation of Africa RISING research projects and government research organisations from national and regional levels who were involved as implementing partners with CGIAR centres.

As illustrated in Figure 2, this research focused on four kebeles, two in the Lemo woreda located in the Southern Nations, Nationalities, and People Region (SNNPR) region, and two in the Basona Worana woreda located in Amhara region. Of the two research kebeles in each woreda, Africa RISING ensured that one of the kebeles selected had better access to the market than the other kebele for comparison. The farmers in both woredas operate within the Ethiopian highlands mixed crop-livestock farming system context, but there are some differences in land use, population density characteristics and biophysical conditions (See Table 1). For example, farmers in Lemo woreda have smaller average farm size, lower proportion of grazing lands and farms at relatively lower elevation range (thus lower incidence of frost) compared with farmers in Basona Worena woreda.

Table 1. Land use and population characteristics of *woreda* study locations

Land use and population *characteristics*	***Basona Worena* woreda**	***Lemo* woreda**
Land area (km²)	1,399	354
Elevation range (masl)	1,980 – 3,000	1,501 – 2,500
Main agro-ecology zone (%)	Highland (*Dega*)	Midland (*Weyna Dega*)
Average Annual rainfall (mm/yr.)	1,100	1,100
Minimum - maximum temperature (°C)	6 - 20	15 - 20
Total population in 2007	120,930	118,594
Percentage of population in rural areas (%)	95	92
Population density (km²)	100.1	437.1
Land use (%): land under cultivation	47	86
Grazing land %	13.1	4.2
Forest, shrubs and bushland %	8.5	6.2
Other land %	31.1	3.6
Average farm size (ha)	1.7	1.2
Major soil type	Cambisols, Vertisols	Nitisols, Cambisols
Major crops	wheat, barley, faba bean, *teff*, oat and pea	wheat, faba bean, *Enset (Enset ventricosum)*, oat, coffee, pea and fruits
Major livestock enterprises	cattle, sheep, horse, donkey and poultry	cattle, sheep, donkey and poultry

Sources: Population data are from CSA (2007); other data *woreda* reports

[1] CGIAR - Consultative Group of International Agricultural Research

Rationale for the focus on livestock innovations

This study narrowed its focus to investigating the innovation processes associated with livestock systems for two main reasons. First, a broad focus on both crop and livestock systems would have spread research resources too thinly to enable the depth of analysis needed to inform policy and practice usefully. Second, livestock systems have received limited attention in Ethiopia from research and development actors, despite livestock productivity remaining low and domestic demand for livestock products expanding (Negassa et al., 2012). This is despite Ethiopia having the largest livestock (mainly cattle) population in Africa with strong potential to contribute to its economy (Shapiro et al., 2017).

Livestock systems in Ethiopia mainly comprise a mixed crop-livestock production system in the highlands and a pastoral production system in the lowlands. The sector underperforms compared with Kenya and other East African countries with similar potential (Negassa et al., 2012). In the highlands, livestock provides multiple benefits: draft power, animal source foods, transport, assets for security, and income sources. According to Negassa et al. (2012), highland farmers primarily keep cattle for draft power (about 45%) and dairy for domestic consumption (about 25%), with commercial sales of dairy products and meat being of secondary economic significance. Despite the increasing domestic demand for livestock products presenting a new opportunity for farmers, their ability to benefit from this opportunity is constrained by interrelated productivity challenges related to feeding, animal health, and breeding (Shapiro et al., 2015). These farmers are mainly supported by state-driven and crop-dominated agricultural development strategies (Asresie et al., 2015), which are largely concerned with increasing the productivity of cereal staple crops (Shapiro et al., 2017). Compared to the crop sector, the livestock sector has received limited attention from successive Ethiopian governments, and its productivity in terms of meat and milk output remains very low (Negassa et al., 2012). Livestock feed scarcity is the major national issue where the majority of the farmers in Ethiopian highlands largely depend on low quality crop residue to feed their livestock. The high cost and low availability of good quality feed from forage and fodder is one of the major constraints to increasing productivity of livestock (Shapiro et al., 2015).

The focus of the multilevel IPs in respect of livestock systems was on feed scarcity, as this issue was identified as the main issues through diagnosis studies conducted by the national platforms (For more details see Lema et al., 2021). Table 2 presents the livestock technological options introduced by the multilevel IPs to reduce feed loss and enhance the availability of quality feed. Our study aimed to understand their sustained utilisation two years after the multilevel IPs ceased to function.

Table 2: Livestock technologies introduced through the multilevel IPs in the study woredas

Options to address livestock feed scarcity	*Livestock feed technologies*	*Number of farmers in FRGs*	
		Lemo	**Basona Worana**
Facilities to reduce feed losses and improve feed quality	Improved livestock feed storage shed	10	14
	Improved cattle feed trough	6	9
Cultivated forages to increase quality feed biomass	Oat-vetch mixture (rain-fed)	35	42
	Tree lucerne	60	56
	Sweet lupin and fodder beet	12	8
	Faba bean-forage intercrop	64	20
	Oat-vetch mixture (irrigated) for sheep fattening	7	0

Source: Author's own compilation based on interviews and review of project documents

Case study methods

To explore directly what IP activities, actions and arrangements account for the sustained use of innovations with participating farmers and other members of the multilevel IPs and provide in-depth insights, a case study research method was used that involved multiple evidence sources that were interrogated using a range of methods (Yin, 2013). Africa RISING was selected for this study due to its multilevel IP structure and its significance to focus on various technologies introduced to improve the livestock system, as discussed in the previous section. The University of New England (HE18-220) and ILRI (ILRI-IREC2018-19) granted human research ethics approval for this research.

In 2018, 48 key informant interviews (KIIs) and four focus group discussions (FGDs) were conducted for this study (Table 3). At the time of data collection, two years had elapsed since the multilevel IPs had ended in 2016. This time gap allowed assessment of the degree to which innovation outcomes had been sustained post-intervention. Three criteria were used to recruit participants who had been members of the multilevel IP: (1) level of IP membership (FRG/kebele, woreda, or national), (2) type of stakeholder group they represented (farmers, researchers, university, government, or NGOs), and (3) a degree of engagement in livestock-related IP activities (all high). Concerning criterion 3, farmers as FRG members were only considered for selection if they had adopted two or more of the introduced livestock technologies listed in Table 2. Each of the KIIs and FGDs took around one to two hours to complete. They were audio-recorded and carefully transcribed from the native dialect into English.

Table 3: Data collection methods, sample size, and types of data gathered

Data collection methods (Total)	Sample size per IP (number of participants)			Data gathered
	National IP	Woreda IPs	Kebele IPs /FRGs	
48 KIIs with national, woreda, and kebele IPs and FRG members representing researchers, universities, government, NGOs, and farmers.	5	15	28*	Individual IP members' views and their experiences with the IPs, their participation and roles in events and on-farm activities, incentives, outcomes attained, and issues faced in sustaining the outcomes.
2 FGDs with woreda IP members (one per woreda IP with 6–7 participants each).	N/A	2	N/A	Collective view on outcomes obtained, their roles in sustaining the outcomes, woreda-specific issues, support available, the effect of multilevel IPs, and lessons learnt to sustain outcomes.
4 FGDs with FRGs (one per kebele with 6–8 farmers each)	N/A	N/A	4	Collective farmers' views on their participation in multilevel IPs, the outcomes they obtained, and issues they experience in sustaining the feed innovations.

**23 farmers and five DAs*

Interview and focus group discussion transcripts were coded and analysed using qualitative data analysis software QSR International's NVivo® version 12 followed the key steps to code and identify themes based on data, as suggested by Braun and Clarke (2006). Accordingly, transcripts were coded in a step-wise process to actively identify and examine themes in context and according to the study's research questions. Following an iterative process of multiple rounds of coding to themes and critically reflecting on these themes, they were finalised. The analysis categorised the themes that affected the sustained use of the technological innovations through multilevel IP interventions. Under each of these, the particular themes, which sometimes overlapped, were identified as either enabling or constraining activities, actions or arrangements concerning sustained use of the feed innovations two years after the support of the multilevel IPs ended. The final selection of themes presented was based on the strength of coding from the KII and FGD. Where there was minimal coding, these themes were not considered further in the analysis. Using NVivo software matrix query, a comparative analysis between sites, stakeholder groups, and across levels was undertaken to examine the variation in subthemes.

Results

The extent of farmers' adoption of farm-level technological components of livestock innovation and their level of sustained use varied depending on the technology and the kebele in which it was applied (Figure 3). Figure 3**Error! Reference source not found.** compares the number of farmers who adopted while the IPs remained in operation with the number who had sustained adoption two years after the IPs ceased. Four technologies which are feed trough, feed storage shed, oat-vetch mixture and tree lucerne were used for this analysis as these were identified by Africa RISING in Phase 1 as being the "farmer-preferred" livestock technologies to be widely scaled out to other woredas during Phase 2 (2017–2021). Feed trough and feed storage shed technologies were structures that were durable once constructed. However, they were not necessarily used as intended, and other structures were observed worn and in disrepair. These structures were costly and initially adopted by fewer farmers compared to the technologies of growing oat-vetch and tree lucerne, even though most of the costs of these structures were covered by Africa RISING. However, oat-vetch and tree lucerne were the least sustained technologies when compared to the initial adoption because they require farmers to annually apply inputs and allocate land (Figure 3). Further detail of the findings that identified activities, actions and arrangements of the multilevel IP that enabled or constrained the sustained use of the feed technologies through thematic analysis are presented below.

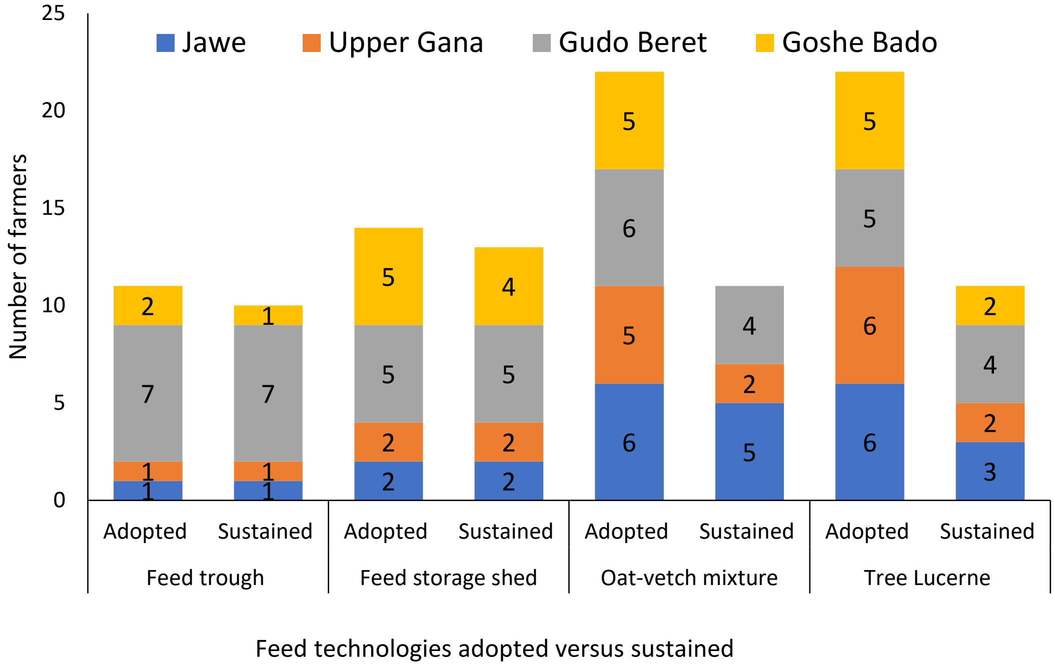

Figure 3: Comparing initial adoption versus sustained use of feed innovations per kebele (23 FRG members interviewed and data examine uptake at kebele level)

(a) Enhancing farmers' technical skills in feed innovation

The data indicated that due to the farmer-centric learning activities facilitated through the multilevel IP there were significant changes in farmers' know-how about improved livestock feed systems that enabled sustained use of feed technologies. The outcome related to farmers' improved technical knowledge was the most significant outcome attained through the multilevel IPs learning activities facilitated as perceived by the stakeholders and farmers interviewed. The learning and knowledge exchanges were facilitated both vertically across the levels and horizontally between same-level IPs and beyond. These outcomes are related to three areas: knowledge of the feed innovations, forage seed production and dairy value chain knowledge through knowledge exchange visits to advanced dairy farmers in neighbouring kebeles.

Firstly, farmers improved their technical know-how to produce, manage using improved feed storage sheds, and use the new feed innovations using improved feed troughs, thus enhancing productivity and efficient utilisation of the feed innovations with existing feed resources. According to all the woreda stakeholder groups interviewed, previous attempts to introduce feed technologies had achieved limited success, not because of a lack of technologies, but rather because of a lack of the embedded "know-how" to use those technologies effectively. For example, in Basona Worana, the stakeholders indicated that despite annual government distribution of millions of tree lucerne seedlings to farmers over the last 30 years to establish tree lucerne on soil bunds[2], farmers lacked basic knowledge on how to effectively plant, manage and utilise tree lucerne for livestock feed and other uses. Before the multilevel IP interventions, farmers in Gudo Beret kebele complained about the already established tree lucerne trees on soil bunds were unutilised that grew too tall and attracted birds that destroyed their crops. The multilevel IP structure addressed the technical knowledge problems related to tree lucerne utilisation for feed and other multiple uses by bringing together the diverse capabilities at the farm level and through to the national level using IP regular meetings and training linked to on-farm trials and field days. On-farm demonstrations were held where farmers were trained on planting, harvesting, storing and mixing tree lucerne foliage both as a green or dry fodder with crop residues to feed and nourish their livestock. During field days, the multiple benefits of tree lucerne were demonstrated to farmers, and information was provided on its high nutritional value, its use as a green fodder during the dry season, its value for bee feeding, and the possibility of using the stems to make farm tools. Almost all farmers across the study sites reported improved technical knowledge to produce, manage and effectively utilise both the newly introduced and existing (crop residue) feed resources.

Secondly, the national-level IP researchers' deliberate integration of training on forage seed production techniques addressed the lack of forage seed supply for interested farmers. It directly enabled farmers to retain seed after harvesting so they could continue to produce improved forage crops independently. As stated by one IP member, who was a university representative on the Lemo woreda IP:

> *The lack of private or public forage seed sources was the main problem for advancing improved forage technologies in rural areas. Even if seeds are found, it is expensive. Enabling Africa RISING farmers to produce their own seeds is creating access to forage seeds locally.*

Thirdly, farmers' exposure to commercial production systems through informal links with dairy farmers in neighbouring kebeles and their increased knowledge about market opportunities empowered them to pursue further advances in commercial production. The farmers claimed that feed innovations were the first and vital step towards realising their

[2] Soil bunds are constructed on the farm to slow down the runoff from erosion to conserve soil and water.

commercial production goals. The multilevel IP structure was instrumental in facilitating farmers' exposure through exchange visits and learning events organised within and outside their kebeles, including a visit to an advanced crossbreed dairy farmers' cooperative. The structure helped to facilitate cross-site learning between the woredas (kebeles) and beyond. For example, the national IP facilitated learning across woredas during the national IP meetings and through organising exchange visits between woreda and kebele IP members. Similarly, the woreda-level and kebele-level IPs facilitated more cross-scale learning between kebeles and FRGs, respectively.

Overall, farmers and stakeholders developed capacities that enabled them to make more informed decisions on improving livestock feed systems. Despite some farmers reducing their use of introduced feed innovations once short-term support from the multilevel IPs ceased (Figure 3), their capacity for innovation had nevertheless been enhanced, thus helping them to make informed decisions on producing feed resources at a low cost. For instance, farmers started using their knowledge to improve the utilisation of existing feed resources (crop residues) and initiated dual-purpose crop varieties as a low-cost feed option based on criteria that maximised both grain yield and crop residue biomass. Also, interviews with livestock nutrition scientists represented on the national IP revealed an improved collaboration with crop breeders because of their interaction within the IPs. They indicated that breeders who used to focus solely on grain yield were now also aware of the value of crop residues in their crop breeding activities, thus shifting their focus to maximising the benefits of dual-purpose crops. Such improvements in the innovation capacity of farmers and shifts in crop breeders' activities are examples of innovation and partnerships that endure beyond the funded program period.

(b) Addressing differences in farmers' needs for feed technologies

The study found that the feed technologies were tailored to the general feed scarcity problem farmers were facing but were less aligned to meet the specific needs of individual farmers, which affected the level of sustained use of feed innovations. *Figure*Figure 4 presents data on two types of farmers distinguished according to type of livestock production, and shows how continued use of the feed innovations differed between these types. The first type is subsistence production (65% of the group), i.e. farmers who traditionally depend more on crop production and keep local livestock breeds primarily for subsistence use (such as draft power and transport) rather than for direct economic benefits. These farmers represent the majority of the farmers across the four kebeles. The second type is commercial production (35% of the group), i.e. farmers running crossbred livestock for commercial purposes, such as small-scale commercial dairying, established before multilevel IP initiation. For the latter type of farmer, use of feed innovations complemented their investment in crossbred dairy cows that give more milk and is likely to lead to improved economic returns. However, these farmers were in the minority. Figure 4*Figure* shows that all of the commercial farmers were from Jawe and Gudo Beret research kebeles, which Africa RISING initially identified as kebeles with relatively better market access compared with the other two kebeles, from Lemo and Basona Worena woreda respectively. The two farmer types differ in terms of resource opportunities and the income-generating potential from their livestock, which affected their decisions to allocate land and other resources for continued utilisation of feed innovations.

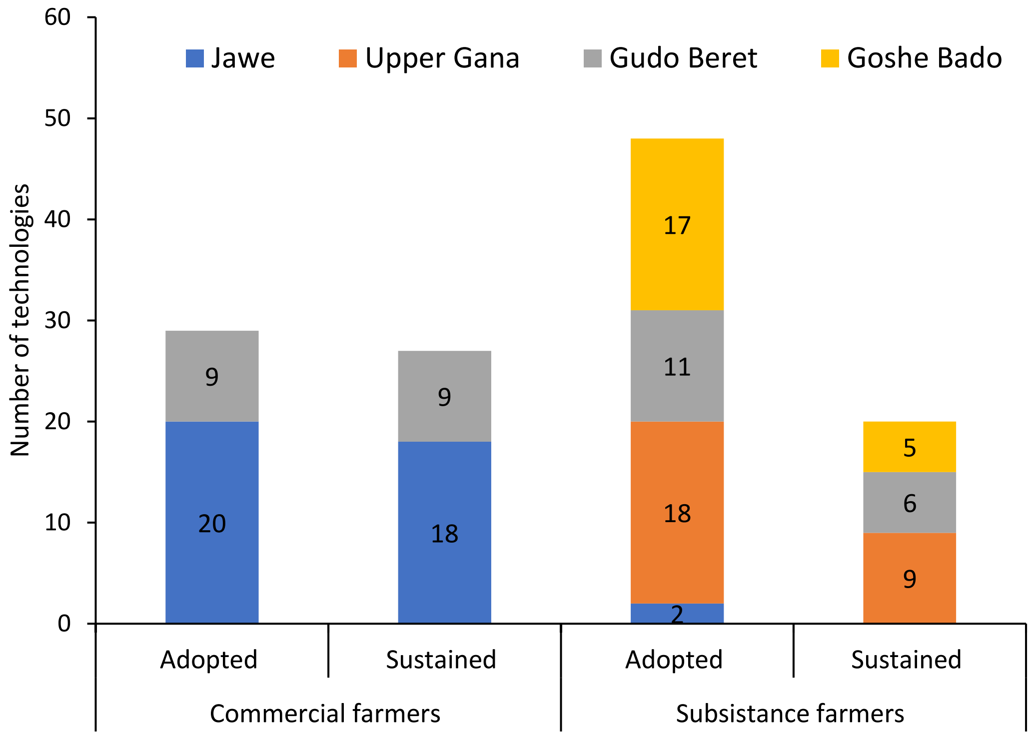

Figure 4: Number of feed technologies adopted and sustained by commercial (n=8 or 35%) and subsistence farmers (n=15 or 65%) interviewed in the four kebeles.

As illustrated in Figure 4, there was a greater difference between the initial and sustained adoption of the feed technologies among subsistence farmers than among commercial farmers. Despite their increased technical knowledge, subsistence farmers were more likely to discontinue the use of the feed technologies and only retain a few feed innovations two years after the multilevel IPs were phased out.

Although both types of farmers regarded the feed technologies as important, their respective decisions to continue utilising these technologies depended on their preferences.

Commercially-oriented farmers were already familiar with raising livestock for commercial production (e.g., crossbreed dairy farms or fattening of oxen) before the multilevel IP intervention and hence had an existing business interest in improved feed technologies that would improve their potential livestock productivity and income. Despite being fewer in number, these commercially-oriented farmers reported that the feed innovations they adopted reduced feed costs and increased milk production, as they used higher-productivity cattle breeds such as crossbred dairy cows for increased milk production and improved income. Some of them started thinking ahead to establish dairy cooperatives. For example, in Lemo, farmers who experienced an exchange learning visit to advanced dairy farmers, in another kebele, spoke of the advantages of organising themselves as a cooperative to improve access to inputs and services. To realise such advantages, however, farmers need to formally organise themselves with institutional support. An exception to this was in Jawe kebele, where one commercial dairy farmer who was the kebele's ex-administrator and who transported his milk to his shop in Hosanna town motivated other resource-rich farmers to operate collectively. He stated that:

> *I invested USD2,150 for electricity supply to start milk processing and establish a dairy cooperative by extending membership to farmers to increase our production scale. I am certain that once farmers realise the benefits, they will buy crossbred dairy cows. I also plan to provide a breeding bull service to members.*

Through the participatory joint learning activities among farmers during the on-farm trials, field days, and IP meetings, close relationships developed between farmers and knowledge was exchanged horizontally that attracting many of the subsistence farmers to a commercially oriented farm business. All farmers indicated that their practical experience in improved feed production and utilisation with the IPs improved and they spoke of a rise in new demand among farmers for starting a dairy or livestock-fattening business. They recognised such a transition requires significant investment and risk management, and indicated how they are constrained by limited access to affordable finance, breeding, and veterinary services.

However, only a few of the better-off farmers from the subsistence-oriented farmers started to take risks and invest in commercial production to improve their income. These investments included purchasing crossbred dairy heifers from commercially oriented farmers, allocating more land for oat-vetch cultivation, constructing larger feed storage sheds, and constructing multipurpose traditional feed troughs to feed and water their livestock.

In contrast, the resource-poor, subsistence-oriented farmers achieved no short-term economic benefits from investing in feed innovations. This is important given that this type of farmer was in the majority. As one such farmer explained:

> *Although we know improved cultivated forages increase milk production, we do not benefit that much because of low productivity of indigenous cows. We lack the resources to buy crossbred cows to increase our productivity.*

Type of farmer influenced the sustained use of several feed technologies. First, individual farmers' feed technologies were not sufficiently tailored to address the competing demands of producing high-biomass crops over high-quality forage crops. Subsistence farmers who kept local (less productive) cattle breeds found it uneconomical to increase land allocation to produce high-quality forage biomass or invest in the feeding and storage structures to minimise feed loss. Furthermore, the estimated 30–50% reduction in feed loss using the feed trough and feed storage sheds was apparently not sufficient to convince subsistence farmers to invest in their construction. In the end, most of the subsistence farmers chose to remain with their traditional practices of producing high-biomass crops for crop residue that can be produced at minimum cost.

(c) Addressing location-specific contexts

The actions taken by multilevel IPs to tailor technologies to the different locations were not sufficiently strong to ensure continued use of the new feed technologies. The location-specific issues identified were related to land size, type of grazing management, and the kebeles' exposure to adverse weather conditions such as frost. Although woreda-level IP stakeholders appreciated farmers' decisions to allocate their limited land to forage production as a significant outcome of the IP, sustaining such land-use changes was affected by local land scarcity. Farmers allocated a fraction of their productive cropping land to sow introduced forage crops such as oat-vetch mixture.

In Basona Worana woreda the average farm size per household is 1.7 ha, which is larger than the 1.2 ha average farm size in Lemo woreda (Table 1). For instance, subsistence farmers in Goshe Bado kebele (in Bason Worana woreda) produced sufficient crop residues for livestock needs, and some even had a surplus to sell to urban dairy farmers. Hence, there was less demand for new feed technologies, limiting their uptake. Within this kebele, two other farmers modified the feed storage and feed trough innovations for other purposes (housing sheep and domestic dwelling). Some subsistence farmers in Goshe Bado kebele indicated that they reverted land allocated for oat-vetch forage to other crops (see Figure 4) because they produced enough crop residue, but also because of the negative impact of weeds, which remained for several years following the use of the land for oat-vetch forage.

Commercial farmers who produced limited crop residues due to small land holdings, particularly in Lemo woreda, were nevertheless able to integrate and sustain forage production using alternative areas. Despite limited land available, for the alternative feed options introduced by the IPs, farmers were able to select and integrate low-cost and productive (biomass) feed technologies capable of addressing feed scarcity. These inexpensive technologies included: oat-vetch mixtures, faba bean-oat intercrops and Desho[3] grass. One of the commercial farmers from Jawe kebele stated that:

> *So, I produce limited crop residue from my small cropland and depend more on livestock. I manage to integrate productive forages such as oat-vetch with a short growing season that allowed me to double-crop forage and food crops.*

The introduction and promotion of different types of forage provide a choice for farmers that fitted their land holding. Desho grass and faba bean-oat intercrops were the two most highly preferred forage options among commercial farmers in Lemo, as they were productive and adapted to agroecology. The highly productive Desho grass was planted on soil bunds and marginal and unused lands and farmers would harvest up to three times per year and "cut and carry" for livestock feed. The faba bean-oat intercrop was developed due to researchers' observations of the traditional practices of farmers in both woredas. During critical feed shortages, farmers traditionally allow self-sown weeds to grow among the faba bean or wheat crops and use the "cut and carry" method to feed their livestock on these weeds. By replacing the self-sown weeds with a more productive improved forage crop, the researchers effectively demonstrated the benefits of intercropped forage without compromising the productivity of the main crop.

Traditional unrestricted or "free" livestock grazing without fences presented a constraint to the establishment of tree lucerne on the soil bunds. It was intended that the tree

[3] Desho grass was not introduced, but rather promoted through the multilevel IPs in Lemo.

lucerne would stabilise soil erosion, improve soil health, and provide a regular harvest for feed. According to researchers represented on the national-level IP, tree lucerne requires both the exclusion of livestock from the new plantation for two years and constant care until it grows tall enough to be beyond the reach of grazing animals. Woreda and kebele government stakeholders indicated that restricting grazing was a solution, but farmers indicated this restriction would be difficult to implement because they have insufficient feed for stall feeding. An exception was a case in Gudo Beret kebele where an NGO supported farmers to plant tree lucerne on soil bunds and free grazing was also temporarily restricted through community by-laws. Finally, adverse weather conditions were a constraining factor. Frost, in particular, negatively affected the production and survival rates of vetch seed production and the growth of tree lucerne in Basona Worana.

The effective response of the woreda IPs to some of these challenges was limited due to various issues including lack of a deliberate effort to recognise non-technical issues such as supporting farmers to develop community by-laws to restrict grazing. Interviews with the Africa RISING site coordinators identified three main challenges encountered when attempting to respond to free grazing or frost issues. First, there was no specific budget for the woreda IP to stimulate local actors to take joint responsibility to identify and address local issues independently. Second, given the competing demands on stakeholders' time, it was difficult to schedule a learning event at a time that suited all IP members. Third, insufficient time was allocated for discussion and negotiation during single-day IP events, as all technical issues concerning crop, livestock, and natural resource management needed to be covered.

FGDs with woreda IP members highlighted that some of the issues were related to the membership of the IPs. Most national IP members were CGIAR researchers and implementing partners from government departments, and there were no members who had the authority to negotiate institutional arrangements in respect of devolving the roles between organisations. The participants believed that if decision-makers from relevant organisations, such as a woreda cooperative office, were involved within their mandates, they could not only assist farmers to organise themselves as cooperatives but also develop community by-laws to partially restrict free grazing. Similarly, the regional research centres could also introduce different vetch varieties, engage farmers to identify frost-resistance varieties or connect farmers to forage seed producers in areas not affected by frost.

There was also tension between the actors representing the crop and livestock sectors, as the livestock experts continued to push for greater attention on their sector, including within the IPs. Woreda stakeholders and farmers often raised similar issues about the limited government attention for many years on the livestock sector and how the IPs had favoured crop interventions over livestock innovations. Examples are given included interventions, including by Africa RISING, which targeted kebeles producing major crops such as wheat when selecting project intervention sites that have been clustered by the national government to inform crop technology interventions. A specific example was mentioned during FGD with Basona Worana woreda IP members where Woreda Office of Agriculture officials subsequently abandoned faba bean-oat intercropping for livestock feed that began through on-farm trials and had maintained farmers' interest. This abandonment arose because officials annually planned to increase land allocations to major staple crops, and viewing the integration of forage into the wheat crop was contrary to this plan. These decisions indicate a greater focus on crop production than on livestock management.

The development of multilevel IPs was an institutional innovation in itself. During their period of operation, they were the primary source of technical knowledge and input support available to farmers adopting the feed innovations. The multilevel IP structure improved the existing weak linkages and collaboration specifically among the technical actors, and enhanced learning within and across the levels to enhance feed innovations. However, insufficient negotiation with decision-makers across levels limited their impact across levels and addressed the important institutional arrangements that constrained farmers' sustained use of feed innovations.

(d) Establishing farmers' access to forage seeds

Sustaining and enhancing forage use requires a reliable supply of forage seeds and associated technical knowledge to produce, manage, and utilise feed technologies. To make seeds available and provide technical support locally, the focus of the multilevel IPs was on building individual farmers' or livestock experts' technical capacity. However, such individual-level capacity is constrained by a lack of economic benefits for the subsistence farmers and frost damage in specific areas that limit forage seed production and retention by individual farmers, resulting in a shortage of seed supply. Except for tree lucerne seedlings in Basona Worana, there was no reliable source of forage seeds in the study sites.

Woreda-level and kebele-level FGD participants identified two opportunities for creating and strengthening existing local institutions to address access to forage seeds. The first involved supporting interested FRG members in establishing a forage seed business, as some of them saw a significant advantage in the forage seed business due to premium prices. A researcher from the Lemo woreda IP stated that:

> *FRGs could have specialised in community forage-seed multiplication and linked to reliable markets because forage seeds are expensive and are currently being sold from USD 10–35 per kilogram and are also locally unavailable, opening new opportunities for farmers*.

The second opportunity involved strengthening the Farmer Training Centres[4], an existing government initiative across the kebeles. A typical example was found in the Upper Gana kebele, where the crop and livestock DAs had established nursery and forage sites within the Farmer Training Centre that they managed. The DAs were taking on this initiative on top of their regular workload, so the output of seeds/seedlings was not high. The woreda FGD participants indicated that the activities of the multilevel IPs could have been more strategically aligned with such existing initiatives to support the establishment of a forage seed supply system and help farmers to capture new opportunities. Both of these opportunities were recognised after the multilevel IPs had ceased to operate. The interviews and discussions undertaken for this research provided all participant stakeholders with the opportunity to reflect on their work as platform members, and they had come to question the sustainability of the livestock innovations. Once the multilevel IPs ceased to operate, the ownership and support levels for the livestock feed innovations from the woreda and kebele technical stakeholders faded. As the technical stakeholders involved were not decision-makers, they could not address the interlinked and emerging issues that are crucial for farmers to sustain and enhance feed innovations.

In summary, the results identified how the multilevel IP activities, actions and arrangements influenced the sustained use of the feed innovation outcomes. In some cases, the activities, actions or arrangements constrained the sustained utilisation of the introduced feed technologies, but in other ways, they enabled their continued use. The multilevel IPs engaged expertise from various levels and decentralised to provide farmer-centric and on-farm technical support that enhanced innovation capacity around feed innovations, which elevated farmers' interest in commercial livestock production such as dairy. However, the expected innovation outcomes of the multilevel IP structure were not fully realised. The multilevel IP support

[4] Government established Farmer Training Centres, which are managed by Development Agents in each kebele with the aim to improve the reach and effectiveness of agricultural extension and farmers inclusion in technology development.

generally focussed on feed systems transition at farm level but the farmers were constrained by problems above the farm level, which constrained the sustained use of livestock feed innovations. The farm-level technical interventions were uniform and less tailored to meet the distinct needs of subsistence farmers and location-specific contexts. Above all, most farmers (i.e. subsistence farmers) were unable to put the new and improved feed technologies they initially adopted into economic use mostly because of interlinked barriers they faced, which would have required actions above farm level. Creating a conducive environment requires multilevel IP interventions above the farm level such as organising farmers to have access to better and reliable inputs and services, supporting the establishment of community bylaws to reduce the impact of free grazing and other complementary changes through facilitated negotiation among diverse actors and these were somewhat overlooked. Overall, while some commercial farmers did experience a sustained economic benefit, most subsistence farmers seemed not to see the benefit in continuing their use of the feed innovations, and they appear to be returning to their traditional practices.

Discussion

This study examined whether and how the activities, actions and arrangements of multilevel IP influenced the continued use of livestock feed innovations during the post-intervention period. The main enabling learning activities, actions by different actors and institutional arrangements facilitated through the multilevel IP were associated with farm-level activities that increased farmers' technical knowledge about the feed innovations, increased productivity arising from the innovations among commercially oriented livestock farmers, and low-cost feed technology options that provided increased feed biomass for farmers with limited cropland. The main constraining activities, actions and arrangements were related to activities above farm level that resulted in low returns for subsistence farmers from their investment in adopting some of the innovations, particularly where they were operating in a weak value chain characterised by inadequate access to inputs and associated services. Addressing such higher-level issues requires negotiation among key decision makers across levels to align or create new institutional or organisational support systems to enable farmers to make the transition to improved feed and livestock systems. Other specific constraining issues are also related to uncontrolled grazing and frost damage. In the discussion below, the multilevel IP structure's intermediary role in these enabling and constraining themes are illustrated using Venn diagrams (Figure 5 and 6). This synthesis of the findings is based on the earlier conceptualisation of the multilevel IP (Figure 1) as a model for fostering a combination of farm-level technological and system-level organisational and institutional changes that could ensure sustained changes and a durable impact.

The role of the multilevel IPs in enabling sustained use of feed technologies

As conceptualised in Figure 1, the focus of the multilevel IPs on technological feed innovations was to enable farmers to make transition from a traditional, low-quality livestock feed system (System A) to an intensified, high-quality feed system (System B) that improves livestock productivity and income to sustain the improved feed system beyond project period (System C). Such technological innovation is considered crucial for transforming the smallholder food systems, as identified in a recent study by Herrero et al. (2020). As illustrated in Figure 5, the multilevel IPs activities, actions and arrangements resulted in positive effects in two areas, which complemented existing opportunities with commercial-oriented farmers to achieve sustained use of feed innovations. Firstly, the multilevel IPs contributed through the technical interventions to improved technical skills when combined with farmers' willingness to increase allocation of land to produce forage (a). The improved technical skills and knowledge for utilising feed technologies effectively (a) was where the multilevel structure of the IP addressed the technical limitation and lack of know-how and enabled farmers to continue using the feed technologies (Figure 5).

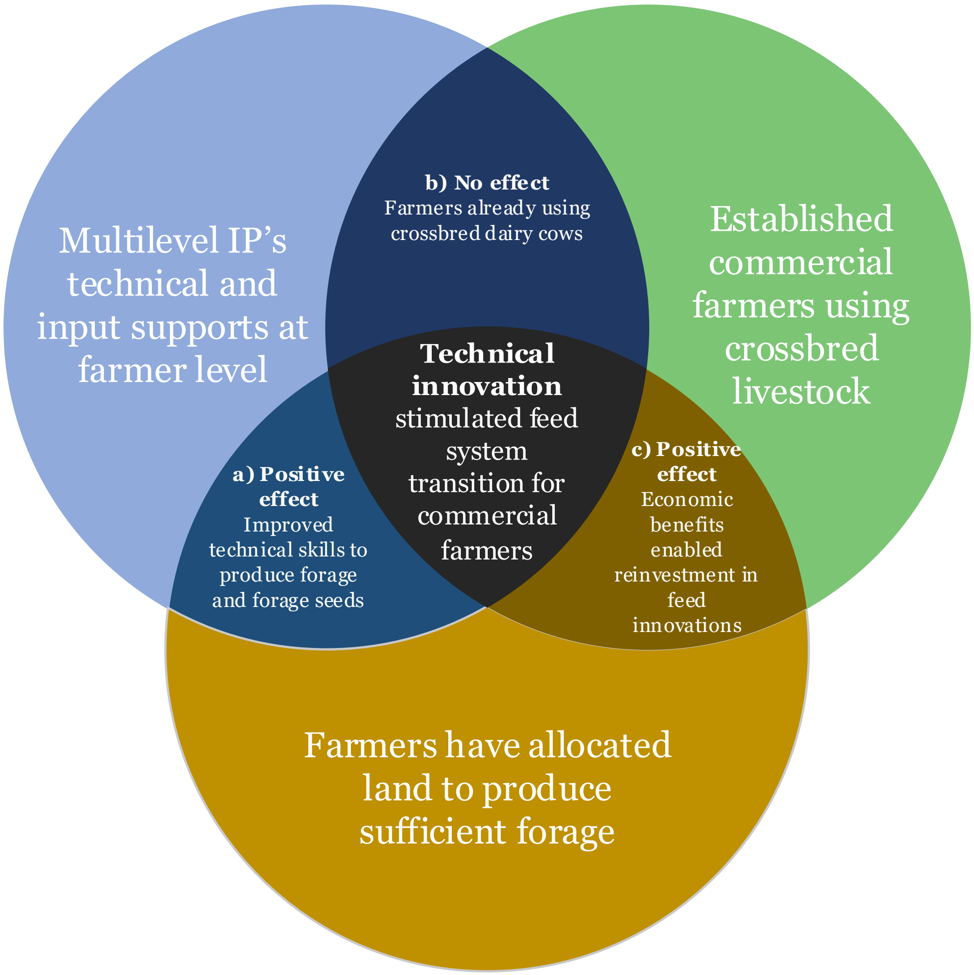

Figure 5: Identified activities, actions or arrangements with the outcome - technical innovation – stimulated feed system transition at the centre of the two-way interactions

Secondly, the multilevel IPs indirectly contributed to improved income for commercially-oriented farmers, who had allocated land for forage production because they could economically benefit from feeding it to productive crossbred dairy livestock. The two-way interactions in Figure 5 between themes of farmer type (commercial) and the multilevel IP (b), produced no 'new' outcomes as commercial farmers were already using complementary innovations, including crossbred dairy cows. Other studies similarly found that farmers who are already using improved breeds and engaged in market activities were primed to achieve the economic benefits of feed innovations once they were introduced (Ayele et al., 2012; Ravichandran et al., 2020).

The multilevel IP activities, actions and arrangements also enhanced interest in commercial production among both commercial and subsistence farmers by facilitating informal links through exchange visits where farmers learnt from advanced peers in dairy and experts within and outside their kebele and IP membership. Multilevel IP did so by facilitating iterative learning within IPs (vertically) and between IPs or beyond (horizontally), where the higher-level IPs facilitated cross-learning for the immediate lower-level IPs or FRGs. Farmers' practical learning for transitioning to a more sustainable feed system is one of the significant outcomes of the innovation process, and this assisted commercial farmers to initiate collective action for commercial production, as observed in the dairy farm in Jawe kebele. Although institutional changes are an essential condition for innovation (Hounkonnou et al., 2012), in our case with commercial farmers it is a farm-level technical innovation combined with learning activities that complemented farmers' earlier engagement in commercial production that triggered feed system transition.

The role of the multilevel IPs in constraining sustained use of feed technologies

For the majority of farmers, however, the finding indicates that the multilevel IP's farm-level technical innovations triggered demands for institutional changes that were unrealised during the IPs in operation. The sustained use of the feed technologies, in this case, was constrained by a lack of support from the multilevel IPs in enabling subsistence farmers to have affordable access to services (such as credit and breeding services) and inputs (forage seeds) to invest in complementary innovations for the use of feed innovations to provide economic benefits and sustain (Figure 6). In some instances, the broader socio-technical context characterised by a predominantly top-down approach to innovation and government priority of crop over livestock contradicts an inclusive and bottom-up approach to livestock innovation facilitated through the multilevel IPs. This was observed where conflicts in prioritising innovation for crop over livestock where, for example, woreda agricultural officials halted the faba bean-forage intercrop due to contradiction with their priority while in other instances the platforms facilitated better understanding between livestock and crop researchers. The strongest identified constraining theme was that farmers did not benefit economically from selling forage seeds, nor did they benefit from improving feeding practices that enhanced their livestock productivity. Thus, the subsistence farmers were operating under different pressure and were not sufficiently motivated to improve their livestock feeding practices given their current dependency on low-quality and low-cost feed systems that could only support less productive livestock.

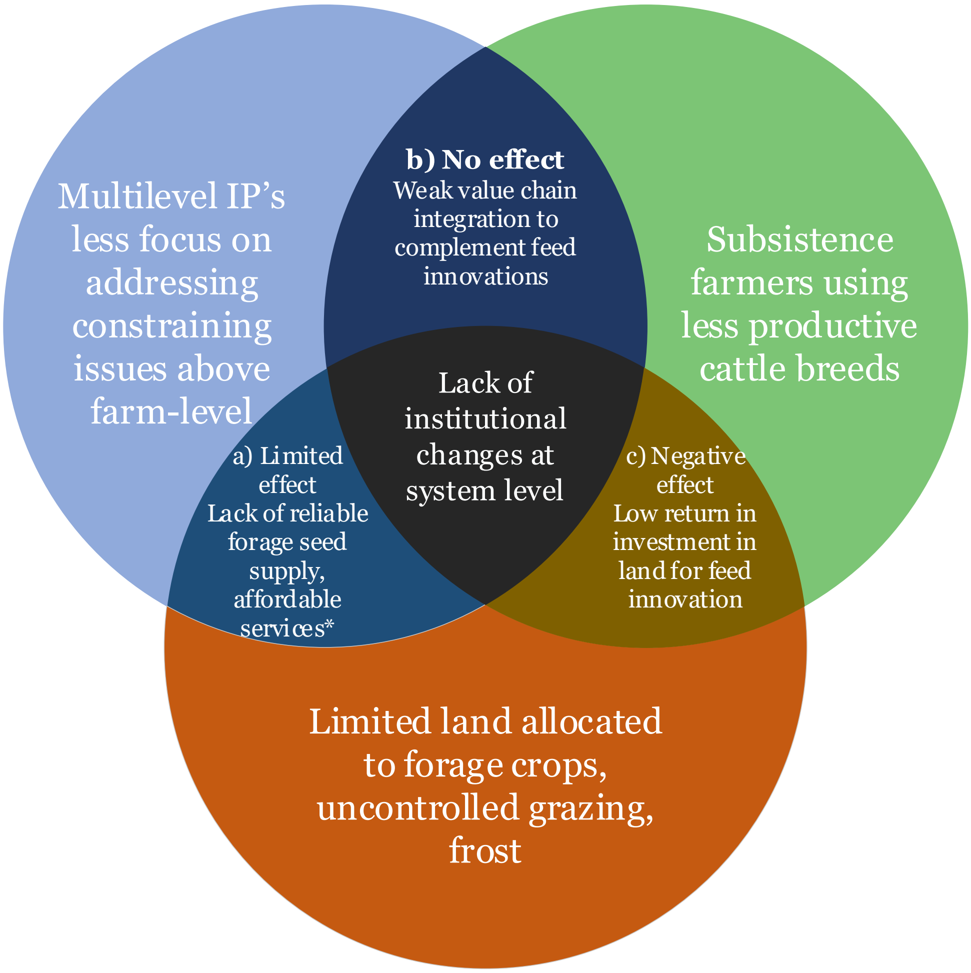

Figure 6: Identified activities, actions or arrangements and the outcome - lack of institutional changes – constraining innovation (farmers transition to improved feed systems) at the centre of the two-way interactions

Therefore, it is necessary to determine how these farmers can reverse the low return on investments (c) to sustain feed innovations. Two important interactions between the subsistence farmers and limited land allocated to forage crops related to value chains and seed supply, respectively could be assisted by the multilevel IP (Figure 6). Greater emphasis on institutional interventions by the multilevel IPs to support farmers to operate collectively to benefit economically is recommended. For instance, community, forage seed producers (organisational innovation) needed to be established and connected to markets to ensure that the identified negative interactions between activities and actions that led to a lack of a reliable seed supply system (a) and low return on investment from selling forage seeds (c) could be reversed. The feed seed shortage is a critical national problem constraining actions to support market-oriented livestock production and to address this problem providing land and credit for private sectors, including farmers cooperatives, to establish feed seed companies was suggested in Ethiopia livestock masterplan (Shapiro et al., 2015). Such higher-level arrangements are vital for subsistence farmers operating under weak institutional support who lack the economic power to address institutional issues individually and need to operate collectively, as earlier studies in the SSA context have identified (Davies et al., 2018; Hounkonnou et al., 2012).

There were also constraints to the sustained use of the feed innovations because the multilevel IPs failed to link farmers to other complementary innovations (b) (Figure 6). Subsistence farmers expressed their emerging need to have collective access to a breeding bull service (b) (Figure 6) in their kebele and that they were prepared to contribute financially (Lema et al., 2021). However, because they lacked access to such complementary innovations (c) they then chose not to allocate land to forage crops, as it would not eventuate in economic benefits, especially for unproductive local cattle breeds. This led subsistence farmers to develop new demands including the need to have access to breeding bull services to shift towards commercial production to achieve economic benefits. Such emerging needs articulated by subsistence farmers arose after farmers developed confidence in the production and utilisation of feed technologies and when working closely with commercial farmers. This finding suggests the need for facilitating multilevel IP learning activities dynamically and paying more attention to accommodate emerging issues during planning and evaluation meetings to carefully identify and adapt actions to address such emerging needs. This could be restricted by the resources allocated to the project, but multilevel IPs have a structural advantage in identifying resources and linking actions across levels through aligning emerging needs with existing initiatives (Lema et al., 2021; Totin et al., 2020; Tucker et al., 2013).

A multilevel structure should have been advantageous in linking actions across levels to enable the higher-level institutional changes required by farmers to pursue collective action through cooperatives in producing and commercialising both forage seeds and dairy products. However, this potential was not fully realised due to insufficient action by relevant actors to bring about institutional changes and create a conducive environment for innovation. Similar IPs in SSA that have succeeded have addressed institutional changes by paying conscious attention to integrating these changes from the outset (e.g., improved value chains) through organising farmers under cooperatives to attract affordable services and inputs and linking them to markets (Hounkonnou et al., 2018; Kilelu et al., 2013).

The way forward

This study found that initiating complementary institutional changes at higher levels of the innovation system and tailoring innovations to the different needs and location-specific contexts of farmers are the most critical activities for enabling sustained use of feed innovations by participating farmers. Although institutional innovation is central, our findings also indicate that technical innovations can also trigger the need for other interrelated organisational and institutional changes, as similarly noted by Kilelu et al. (2013). Due to the complex nature of the issues dealt with during each IP learning event, the expected effect of these events on engaging higher-level decision-makers and initiating higher-level institutional innovations above the farm level was not fully realised. In establishing multilevel IPs to facilitate the combination of the technological, organisational and institutional changes needed for sustained livestock feed innovation, it is important to look beyond the multilevel structure itself and foster the range and quality of stakeholder reconfiguration needed for more integrated problem-solving.

We found that the role of multilevel IPs should focus on facilitating long-term impacts by ensuring system-level change that complements the short-term goal of addressing farm-level technical issues such as feed scarcity. In our case, such system-level change can be achieved, if, at the start, farmers' needs are categorised to aid the development of innovations that complement their production objectives (commercial versus subsistence). Such categorisation helps redefine the starting system (System A) as indicated in Figure 1 where, before IP interventions, subsistence farmers operate in a different system and capability compared to commercial farmers. This could help tailor low-cost feed innovations that can increase forage biomass production for subsistence farmers' needs while high-input feed innovations can satisfy commercial farmers' needs. Although feed innovation to solve the short-term problem was used as an entry point for both types of farmers more focus is needed on facilitating a dynamic innovation process that responds to context-specific emerging needs triggered through the feed innovations. Without such active interventions, subsistence farmers could be excluded from economic benefits as observed in this study. As other authors noted facilitating such dynamic innovation processes requires high-level facilitation and negotiation skill with decision makers that pay closer attention to linking multiple actions across levels through identifying resources beyond the project fund and aligning IP activities with existing initiatives to adapt to emerging issues (Cullen et al., 2014; Kilelu et al., 2013; Totin et al., 2020).

Another important strategy that has emerged from this study involves creating informal links to relevant people and organisations outside the IP structure that could bring in the specific learning experience, expertise or decision makers that are lacking within IPs to initiate specific institutional experiments, as similarly identified by Nederlof and Pyburn (2012). One example is the exchange visits facilitated by higher-level IPs through informal links where participating farmers visited established dairy farmers' cooperatives in neighbouring kebeles were important in empowering farmers to redefine their production objectives toward the commercial production system. Considering most projects operate over a relatively short-term period and have funding limits, sustained outcomes are best achieved if IPs focus on developing the local capacity and aligning IPs activities with existing initiatives.

Stimulating institutional changes within multilevel IPs requires not only decentralising the structure at community levels to engage farmers and local actors to implement pre-identified technical interventions but also, more importantly, decentralising the innovation process to enable farmers and local stakeholders to jointly prioritise site-specific interventions tailored to the needs of different farmer groups. This outcome can be realised if sufficient attention, from the beginning, is given to prioritising the institutional issues linked with the technical changes and determining the strategic engagement of relevant actors and their role in supporting farmers to address institutional constraints. Notably, exit strategies for IP interventions need to be negotiated early in the process among the key potential actors representing existing public and private organisations during its functioning so that their activities can be subsequently embedded within their organisations to sustain the changes beyond the active intervention phase.

A critical challenge exists for multilevel IPs, which are intended to focus on broader system issues across multiple sectors such as crop-livestock-tree systems intensifications in addressing livestock-sector-specific (and value chain issues even more narrowly) while still maintaining their original focus. This was beyond the scope of this research and can be a focus for future research to understand the role of multilevel IPs in dealing with multiple-scale demands across different sectors with strategies focusing on a specific theme (such as livestock value chain).

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