

Proceedings of a workshop and exhibition on promoting productivity and market access technologies and approaches to improve farm income and livelihoods in Ethiopia: Lessons from action research projects

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Through action research and development partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three regional projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads the program's monitoring, evaluation and impact assessment. <http://africa-rising.net/>



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Abbreviations and acronyms

| | |
|---------------|---|
| ADLI | Government of Ethiopia Agriculture Development-Led Industrialization strategy |
| Africa RISING | Africa Research in Sustainable Intensification for the Next Generation |
| AGP | Agricultural Growth Program |
| AR4D | Agricultural Research for Development |
| a.s.l. | above sea level |
| AVCD-LC | Accelerated Value Chain Development-Livestock Component |
| CCPP | contagious caprine pleuropneumonia |
| CIAT | International Center for Tropical Agriculture |
| CIMMYT | International Maize and Wheat Improvement Center |
| CRGE | Ethiopia Climate Resilient Green Economic plan |
| cm | centimetres |
| CP | crude protein |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| DA | development agent |
| DLS | diffused light storage |
| DM | dry matter |
| DOC | day-old chick |
| EIAR | Ethiopian Institute for Agricultural Research |
| EM | effective microorganism |
| ETB | Ethiopian birr |
| FSP | front service providers |
| FTC | Farmers Training Centres |
| FtF | Feed the Future |
| g | gram(s) |
| GDP | gross domestic product |
| GTP I and II | Growth and Transformation Plan of Ethiopia |
| ha | hectare(s) |

| | |
|----------|--|
| ICARDA | International Center for Agricultural Research in the Dry Areas |
| ICRISAT | International Crops Research Institute for Semiarid Tropics |
| iDE | International Development Enterprises |
| IITA | International Institute of Tropical Agriculture |
| ILRI | International Livestock Research Institute |
| ILSSI | Innovative Lab for Small Scale Irrigation |
| IPs | innovation platforms |
| IPMS | Improving Productivity and Market Success of Ethiopian Farmers |
| IWMI | International Water Management Institute |
| IWUA | Irrigated Water Users Associations |
| IVOMD | in vitro organic matter digestibility |
| KLMC | Kenya Livestock Marketing Council |
| kg | kilogram(s) |
| km | kilometre(s) |
| LIVES | Livestock and Irrigation Value Chains for Ethiopian Smallholders |
| LM | logic model |
| m | metre(s) |
| M&E | monitoring and evaluation |
| ME | metabolized energy |
| mj | megajoule |
| ml | millilitre |
| mm | millimetre |
| MoA | Ethiopian Ministry of Agriculture |
| MR | maintain and repair |
| MSP | mobile service providers |
| N | nitrogen |
| N2Africa | Nitrogen for Africa |
| NARS | national agricultural research institutes |
| NBDC | Nile Basin Development Challenge |
| NDF | neutral detergent fiber |
| NGO | nongovernmental organizations |
| No. | number |
| OLS | Ordinary Least Square |
| P | phosphorous |

| | |
|---------|---|
| PAPI | paper-assisted personal interviews |
| PAs | peasant associations |
| PIP | LIVES Project Implementation Plan |
| PMF | Performance Measurement Framework |
| RBM&E | results-based monitoring and evaluation |
| RUSACCO | Rural Savings and Credit Cooperatives |
| SI | sustainable intensification |
| SNNP | State of Southern Nations, Nationalities and Peoples' |
| t | tonne(s) |
| U.S. | United States |
| USAID | United States Agency for International Development |
| USD | U.S. dollar |
| vs. | versus |
| WFD | wetting front detectors |
| WLS | water lifting support |

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Summary

On 8–9 December 2016, ILRI held a workshop and exhibition in Addis Ababa for researchers to share their experiences in implementing action research projects. Action research projects superimpose research protocols on development interventions along commodity value chains and systems to assess their feasibility, effectiveness and outcomes. In the years prior to 2016, ILRI implemented several action research projects in target countries of Africa, including Kenya and Ethiopia.

The objectives of the workshop and exhibition were:

1. To create wider awareness and knowledge about the technologies and approaches that are tested and validated by LIVES, Africa RISING, ILRI Accelerated Value Chain Development (AVCD) and N2Africa;
2. To facilitate the uptake of successful experiences/innovations that combine productivity enhancement and market access;
3. To facilitate dialogue on improving the linkage/partnership between research and development actors and facilitate cross learning.

The expected outcomes of the workshop and exhibition were:

1. Improved awareness about the technical, organizational and institutional interventions tested and validated by the projects;
2. Improved understanding of the role and utility of action research approaches, opportunities and constraints;
3. Enhanced probability of scaling out and up of the tested technologies and approaches to achieve sustainable and market-oriented smallholder agricultural development.

A compilation of papers presented at the ‘Promoting productivity and market access technologies and approaches to improve farm income and livelihoods in Ethiopia: Lessons from action research projects’ workshop and exhibition are included below.

LIVES

LIVES is a collaborative initiative designed by ILRI, the International Water Management Institute (IWMI) and national partners to build upon the success of the Canadian International Development Agency-funded project, Improving Productivity and Market Success of Smallholders in Ethiopia (IPMS).

Initiated in 2005, IPMS helped to create an enabling environment in pilot areas to empower the public sector, smallholder farmers and private-sector agents to increase the production and productivity of crops and livestock through participatory, market-oriented development. The success of the program is attributed to applying innovations systems approaches to identify and exploit opportunities in commodity value chains.

LIVES builds on the success and lessons of IPMS while introducing new approaches and interventions. Successful projects are scaled up and out, focusing on a limited number of value chains and emphasizing the development of sustained capacity that will continue to have impact beyond the life of the project.

<https://www.ilri.org/node/1215>

Agribusiness approaches and methods to promote integration of farmers with markets: LIVES experiences

Dereje Legesse, ILRI

Introduction

The agricultural sector plays an important role in the gross domestic product (GDP) share, employment and export earnings in the Ethiopian economy. In 2012–13, the agricultural sector contributed 42.7% to the GDP, employed 80% of the total population and contributed 80% to export earnings. This makes agribusiness vital to the commercial transformation of the rural sector of the Ethiopian economy (EEA 2014).

Predominated by smallholders, the agricultural sector in Ethiopia has limited access to quality input/service supply and output markets for both livestock and irrigated crops. There is significant demand by value chain actors for technical assistance, improved production technologies, business development services and linkages to commercial agents (Gebremedhin et al. 2012).

Mandated institutions¹ develop the knowledge and skills of agribusiness operators across market-oriented topics. Common topics include business plan preparation, loan appraisal techniques, cost/price calculation, cash flow analysis, marketing and promotion. However, the limited capacity of the mandated institutions to undertake market-led agricultural development hampers smallholders in Ethiopia (Tegegne et al. 2010).

The LIVES Project Implementation Plan (PIP) and baseline surveys identified input supply, service provision, marketing and processing obstacles. For livestock commodity value chain system development, the most mentioned input/service supply-related gaps include genetic improvement, fodder/feed development, veterinary drug supply services, improved beekeeping practices, bee forage development and access to finance. Regarding irrigated crops, the gaps are in the supply of new species and varieties, agrochemicals, farm/irrigation equipment, water pump repair and maintenance services, and water management/water supply systems.

To promote processing/marketing businesses, the most-mentioned challenges in surveys are fragmented production, geographic distance to market, lack of bargaining power and small economies of scale. Safety and hygiene are also identified as major problems in the PIP surveys.

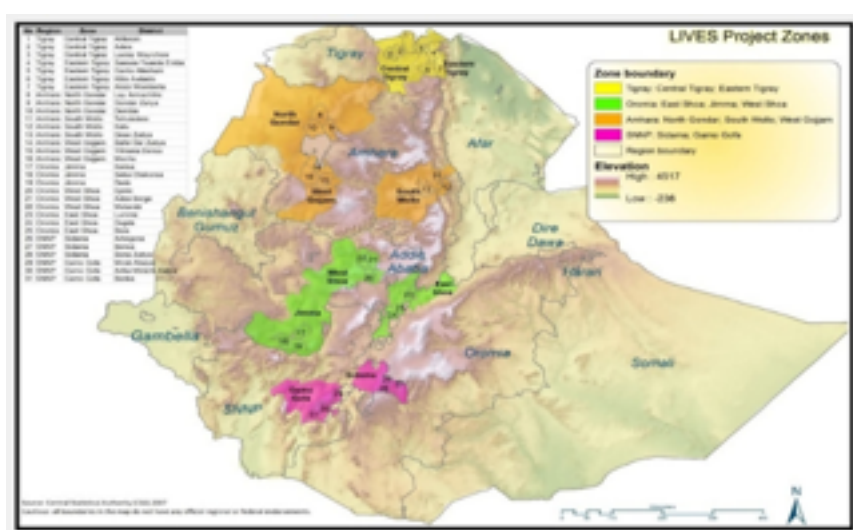
¹ Mandated institutions participate in the capacity development (knowledge and skills) of value chain actors involved in livestock and irrigated agriculture commodity value chains. Mandated institutions in Ethiopia include the Ministry of Agriculture (MoA) (including the Extension, Livestock and Natural Resources Directorates), Micro and Small Enterprises Development Agencies, Cooperative Promotion Agencies, Agricultural Technical and Vocational Education and Training Centres, and financial institutions (microfinance institutions and banks).

Context

The LIVES project aims to promote market-oriented production and value chain development in Ethiopia in collaboration with national and regional partners. In this context, the project designed sustainable approaches and worked on a number of value chain interventions to promote both livestock and irrigated crop commodities. These interventions aimed at increasing access to input/service supply and market opportunities for all value chain actors and service providers by accelerating efficiency and competitiveness in the business sector.

Each intervention targeted both new and existing agribusinesses that engaged in input supply/service delivery and marketing/processing for each commodity with different ownership structures.²

Figure 1: LIVES interventional regions, zones and districts.



The LIVES project works with public and private sector partners to develop livestock (dairy, small and large ruminants, poultry and apiculture) and irrigated crops (fruit, vegetable and fodder) value chains in clusters of 31 districts in 10 zones of the four regions (Amhara, Oromia, State of Southern Nations, Nationalities and Peoples' (SNNP) and Tigray) (Figure 1).

| Zone | Dairy | Beef | Small ruminant | Poultry | Apiculture | Irrigated Agriculture |
|----------------|----------|----------|----------------|----------|------------|-----------------------|
| Eastern Tigray | ✓ | | ✓ | | ✓ | ✓ |
| Central Tigray | ✓ | | | ✓ | ✓ | ✓ |
| West Gojam | ✓ | ✓ | | ✓ | | ✓ |
| North Gondar | ✓ | ✓ | | ✓ | | ✓ |
| South Wello | ✓ | | ✓ | | ✓ | ✓ |
| East Shoa | ✓ | ✓ | | ✓ | | ✓ |
| West Shoa | ✓ | | ✓ | | ✓ | ✓ |
| Jimma | ✓ | | | ✓ | ✓ | ✓ |
| Gamo Gofa | | ✓ | ✓ | ✓ | | ✓ |
| Sidama | ✓ | | ✓ | ✓ | | ✓ |
| | 9 | 4 | 5 | 7 | 5 | 10 |

The intervention areas are selected based on their potential commodity value chain development during the LIVES PIP phase. Table 1 shows the priority commodity value chains and their zonal location in the four LIVES regions.

² The most common business ownership structure in LIVES projects are: public, private, group and cooperative/union (includes the Irrigated Water Users Associations (IWUAs) and Rural Savings and Credit Cooperatives (RUSACCOs)).

Description of the intervention: approach/technology

Using innovation systems and value chain approaches tested and validated in IPMS, the LIVES project introduces and promotes business and organizational innovations to develop selected commodity value chains for both livestock and irrigated crops in and beyond the project intervention areas.

The project determined, designed and promoted an appropriate intervention in the project areas aimed at creating commodity value chain system development on selected livestock (dairy, beef, small ruminant, poultry and apiculture) and irrigated crops (fodder, fruit and vegetable).

The value chain system development interventions focused on business development support services. The major support included basic business skills and knowledge development (organization and leadership skills), linkage (Business to Business – B2B and Farmer to Business – F2B) both for market and financial services, cost/benefit analysis, advice on alternative financing (financial leasing) and cost saving transactions (mobile banking). This support aimed at increasing access to input and service supply for smallholders and market opportunities among the value chain actors and service providers by accelerating efficiency and competitiveness in the business sector.

The targeted businesses and organizations are comprised of different ownership structures categorized as public, private, group and cooperative/union (including IWUA and RUSACCO). The project key input supply/service provision and marketing/processing intervention, for both livestock and irrigated crops, under each commodity are summarized in Tables 2 and 3.

Table 2: Livestock input supply/service provision and marketing/processing intervention

| Commodity | Intervention | |
|-----------------------|--|---|
| | Input Supply/Service Provision | Processing/Marketing |
| Dairy | Genetic Improvement Fodder/Feed Development Veterinary Drug Supply Services Link with financial service providers | Dairy Marketing Dairy Processing (Café & Shop) Butter / Chees Processing & Marketing Creating linkages and formation of marketing groups |
| Poultry | Breed Improvement Fodder/Feed Development Health Services Link with financial service providers | Chicken Trading Chicken Meat Processing Egg Trading / Processing Creating linkages and formation of marketing groups |
| Small Ruminant | Genetic Improvement Fodder/Feed Development Veterinary Drug Services | Live Animal Trading Creating linkages and formation of marketing groups |
| Large Ruminant | Genetic Improvement Fodder/Feed Development Veterinary Drug Services | Live Animal Trading Creating linkages and formation of marketing groups |
| Apiculture | Improved Beekeeping Bee Forage Development Link with financial service providers | Honey Trading Honey Processing Creating linkages and formation of marketing groups |

Table 3: Irrigated crop input supply/service provision and marketing/processing intervention

| Commodity | Intervention | |
|------------------|--|---|
| | Input Supply/Service Provision | Processing/Marketing |
| Fodder | Supply of New Species/Varieties Supply of Agrochemicals/Farm Equipments Link with financial service providers | Green Fodder Processed Feed Creating linkages and formation of marketing groups |
| Fruit | Supply of New Species/Varieties Supply of Agrochemicals/Farm Equipments Supply of Irrigation Equipments Repair/Maintenance Services Water Management/Water Supply Link with financial service providers | Raw Fruit Processed Fruit Creating linkages and formation of marketing groups |
| Vegetable | Supply of New Species/Varieties Supply of Agrochemicals/Farm Equipments Supply of Irrigation Equipments Repair/Maintenance Services Water Management/Water Supply Link with financial service providers | Raw Vegetable Processed Vegetable Creating linkages and formation of marketing groups |

LIVES project agribusiness interventions are identified and designed in a participatory manner with representatives of all value chain actors and service providers. The planned interventions were the outcomes of various activities encompassing commodity platform meetings, capacity gap identification of various actors, field observations and stakeholders' meetings.

The project engaged relevant stakeholders from public to private sectors for intervention planning and implementation. The stakeholders are federal, regional, zonal and district level government offices (Research Institute, Bureau of Agriculture, Livestock and Fishery, Horticulture, Cooperative and Marketing, Women and Children affairs) and private businesses.

In the implementation process, the project targeted both new and existing agribusinesses that are active in the input supply/service delivery and marketing/processing businesses. Partners were highly involved especially those mandated to give business development and financial services.

As of 30 September 2016, the project supported a total of 1,860 agribusinesses. Out of these, 1,422 were engaged in input/service supply and 438 were engaged in marketing/processing businesses (Table 4).

Table 4: Supported agribusinesses as of September 2016

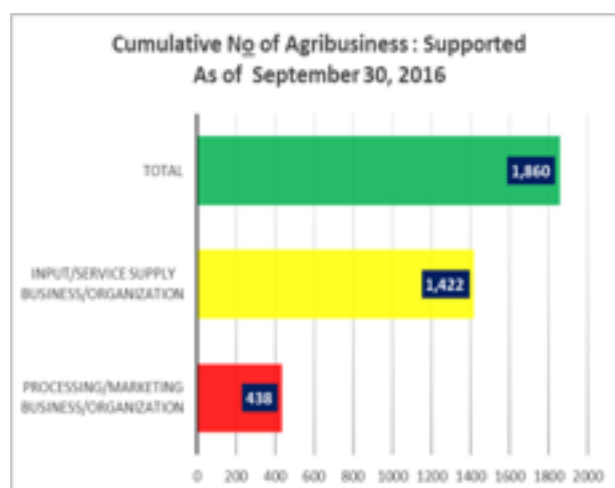
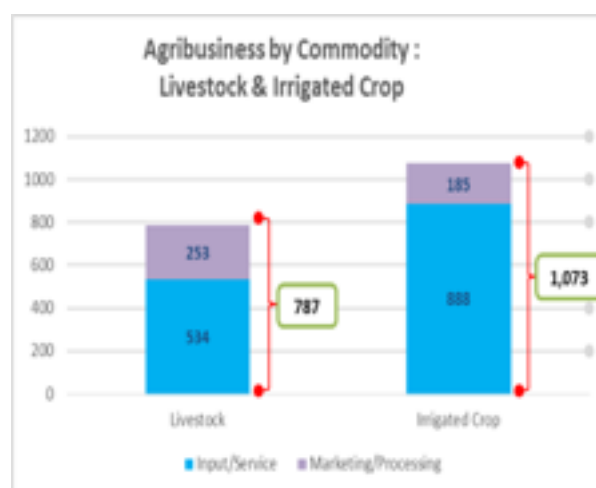


Table 5: Supported agribusiness by commodity



The project facilitated new ideas through commodity platform meetings, new technology demonstrations and other means that led to the establishment of new businesses. Out of the total agribusinesses supported by the project, 453 (24.4%) are newly established. Out of these, 345 businesses were engaged in input/service supply and 108 in marketing/processing.

These interventions resulted in increased access and use of input supply and service providers for smallholders and increased value addition and market opportunities for value chain actors.

In the midterm community survey conducted by LIVES, smallholders who have access to and use of the public extension service (mainly information and knowledge, capacity building/training and linkages supports) are satisfied (49%) and very satisfied (24%).

Key lessons and challenges

To meet the market challenges, the project with partners provided market information, facilitated market linkages and opportunities among the different value chain actors, facilitated collective marketing (groups, cooperatives/union) and promoted local demand. However, in spite of the overall achievements of the project in agribusiness approaches and methods to promote integration of farmers with markets, lessons and challenges were encountered.

In the implementation process, the most realized challenges were: lack of information by smallholders about the availability of improved input/service supply, processing and marketing businesses, financial access to promote agriculture as a business, and the private sector is not yet attracted to doing business in the agricultural sector while the public sector is still the major player. Finally, in a community-owned business, one challenge is lack of empirical cost/benefit data to make a business plan/cash flow. Asymmetric information, moral hazards and free rider problems were also observed.

Market challenges were reflected in a number of platform meetings and coaching/mentoring sessions. Commodity and location-specific market challenges were faced by value chain actors due to improved production, better post-harvest handling techniques and scaling out.

Given the current and future challenges, the most economically efficient ways to enhance realized results are: promote market-oriented extension service, engage financial service providers with alternative financing (leasing) and delivery channels (mobile banking), encourage private business (including family and community owned), integrate with existing women and youth empowerment activities, and ensure future supply/spare part and repair and maintenance services locally for some selected technologies.

Implications for scaling out

Based on cases studies, blog stories and the findings of a mid-term intermediate outcome assessment, the project can suggest some scalable and sustainable agribusiness approaches and methods to promote integration of farmers with markets.

Publicly owned businesses: target Farmers Training Centres (FTCs), artificial insemination technicians, government affiliated microfinance institutions³ and the larger extension service. The initiative to scale tested interventions will need to be undertaken by the public sector as the private sector is not currently attracted to agribusiness.

³ Microfinance institutions where a majority of the share is owned by the public.

Privately owned businesses: include individuals who take the initiative to start and manage a business, such as family-owned enterprises.⁴ The project found that the private sector business model holds great potential for the expansion of market-oriented agricultural development.

Group owned businesses (including community-based groups⁵): organize to access profitable markets by tackling fragmented production, geographic distance to market centres, lack of bargaining power and small economies of scale. The formation targets youth, identified as the drivers of the change process.

Cooperative/union (including IWUA and RUSACCO): largely includes commodity-specific cooperatives/unions for better production and marketing (for example, dairy cooperatives) but also includes IWUA for improved and fair water management and distribution, and RUSACCO for better access to financial services.

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⁴ LIVES promoted family-owned enterprises through engaging heads of the households and family member (males and females age 18 and above) in the production and marketing activities of both livestock and irrigated crops. The project also engaged the family members in the coaching and mentoring session to spark interest in agriculture.

⁵ The LIVES project initiated community-owned businesses for selected interventions in small ruminants like genetic improvement, grazing land management and disease control programs. The project also established community-based breeding groups in Eastern Tigray and West Shoa (Oromia Region). A community-based terminal crossbreeding group was established in Arbogona district, Sidama Zone of SNNP. These interventions enabled better production during the optimal season along with risk management to maximize economies of scale and profitable markets.

Enabling frontline water lifting service providers to reduce risks of crop failure and increase producer confidence in adopting irrigation: LIVES experiences

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Introduction

The government of Ethiopia has launched the Agriculture Development-Led Industrialization strategy (ADLI) to achieve a gradual shift of the economy towards the non-agricultural sectors, industry and services (MoARD 2010). As part of the ADLI strategy, community-based natural resources conservation and improved use of the conserved resources have been intensively implemented over the last 25 years, including enrichment of groundwater and surface water in most of the conserved watersheds. Consequently, new irrigation schemes gradually developed, mostly in the foothills of the watersheds. In the irrigation schemes, new technologies including high-value irrigated vegetables, fruits and green fodder development were introduced to enhance productivity and productive use of conserved water. Extension services intensified to assist the productive use of water through improved market linkages and productivity, and associated inputs and services. Moreover, water lifting technologies, mainly motor, pressurized and treadle pumps, were introduced to make productive use of the conserved low-lying groundwater and surface water resources.

The introduced water lifting technologies immensely contributed to the expansion of irrigation, cultivation of high-value irrigated crops and increased income of smallholders in Ethiopia. The regional Bureaus of Agriculture and Rural Development report showed that a large proportion of the total irrigated area in Tigray and SNNP is irrigated using water lifting technologies. Similarly, the number of water lifting pumps increased in the regions. While the number of water lifting pumps has been increasing annually, the water lifting support (WLS) services, mainly the skills and knowledge to operate, maintain and repair (MR) pumps, access to inputs and spare parts lagged behind. Subsequently, frequent pump failures occurred associated with extended weeks of pump downtime during the dry cropping season. During pump failure, smallholders have to travel long distances with their broken pumps in search of WLS services and inputs. It usually takes weeks or months to get the pumps back into working order which led to substantial yield reduction of high-value irrigated vegetables, fruits and green fodder. During pump failures, farmers had limited access to crop failure-risk reduction mechanisms (pump renting and group sharing or borrowing).

Context

To improve WLS, a cluster of new organizational and institutional frontline services were introduced and tested in 10 selected LIVES zones of Amhara, Oromia, Tigray and SNNP of Ethiopia. The new interventions were organized to provide WLS services initially within the intervention districts and peasant associations (PAs) with a spillover effect to domain irrigation schemes in a cluster way. The purpose of the WLS intervention was to enable frontline water lifting technology MR service providers to reduce risks of crop failure and increase farmers' confidence in adopting irrigation in support of high-value irrigated crops—vegetables, fruits and fodder.

Description of the intervention: approach/technology

The gaps and the need for WLS services were diagnosed during the district irrigated crops innovation platform (IP) meeting and irrigated crops value chain analyses. The irrigated crops IP is a means to bring together different value chain actors and service providers to identify leveraging points along the irrigated crops value chains. The irrigated crops IP consisted of individual members that reflected the value chain actors and service providers: farmers, agricultural input suppliers, traders, food processors and extension service providers (Gebremedhin et al. 2011). The irrigated crops platform members come together annually to diagnose irrigated crops problems, identify opportunities and suggest interventions as leveraging points.

In the LIVES project, diagnosis leverage points along the value chain nodes is a key approach before launching interventions. The leverage point may have a significant impact on improving the irrigated crops value chain stage(s) if interventions are applied (Gebremedhin et al. 2011). Hence, the WLS services were diagnosed as one of the key leveraging points that warrant interventions during the platform discussion. Moreover, the existence of skills and knowledge gradients among the PAs district/zonal/regional towns was diagnosed. Skills and knowledge in WLS services were diagnosed as weak in the irrigated schemes and PAs where the pumps were operating, and relatively best in the large towns where garage facilities for cars are available. The linkages among the WLS service providers were also diagnosed as weak. The components of the WLS services or diversity of the services were diagnosed as limited. Most importantly, whenever there was a pump breakdown, producers had limited crop failure-risk reducing mechanisms.

Based on the diagnosed gaps in WLS services, frontline WLS service providers were established, linkages among WLS service providers strengthened, diversified WLS services enhanced and crop failure risk-reducing mechanisms introduced. Skills and knowledge development were WLS interventions designed to bridge the diagnosed skills and knowledge gaps. To bridge the skill gradient, two levels of private frontline WLS service providers were introduced: front service providers (FSP) and mobile service providers (MSP) in selected PAs and irrigation schemes. The FSP and MSP strengthened and enabled skill and knowledge of WLS service provision. The FSP also linked among each other and with skilful mechanics in the towns to continuously cascade skills and knowledge to the FSP in a sustainable way. The targeted private FSP were farmers working in the schemes who had interest and, preferably, some skills. The targeted FSP were educated youth farmers residing in the irrigation areas and trained to give WLS in the specific schemes. The MSP were residents of the PAs trained to give WLS for wider schemes. For this purpose, 35 FSP and 17 MSP were intensively trained to provide WLS services in Tigray. The FSP and the MSP in Tigray initially trained 180 pump owners. In SNNP, 16 FSP and nine MSP were trained and both FSP and MSP initially trained more than 125 pump owners. The planned WLS service interventions were also included in diversified services according to the needs of pump owners—skills in MR of pumps, create access to input supply and facilitate crop failure risk-reducing measures (pump renting and prior agreed upon group support). There was continuous follow up (coaching and mentoring) on the performance of the frontline WLS service providers and those with the best achievement were motivated with the award of demonstration pump kits.

Results

The primary survey results showed that there was an improvement in saving marketable vegetable produce in both regions, Tigray and SNNP. For instance, in the sampled schemes of Tigray, the majority of vegetable growers indicated that yield loss before the intervention was in the range of 38–63%. After the intervention, vegetable yield loss reduced to 13–38%. The results signify that water stress at any stage of the vegetables is associated with loss of yields and income of smallholders. The initial results also indicate that as the cascading of skills and knowledge towards the frontline WLS service providers are enhanced, a further reduction in the marketable yield loss of vegetables is expected.

The observed reduction in the loss of marketable vegetables is associated with the changes in the frequency of pump failure, duration of pump downtime, diversified WLS services and crop risk failure-reducing mechanisms. In Tigray, the seasonal frequency of pump failure fell from two–four to once per season after the intervention. Similarly, the duration of pump downtime was also reduced from two–four weeks to less than a week in most cases.

The services diversified and WLS providers increased following the interventions (Table I). The diversified WLS include skill-based services (MR, water lifting specification advisory services, and assembly/disassembly of pumps), inputs supply (spare parts, accessories, fuel and lubricant) and crop failure risk-reducing measures (pump renting and facilitation of shared ground insurance and serving to reciprocate agreement).

The number of services diversified and WLS providers increased following the clustered interventions (Table I). The diversified WLS included skill-based services (MR, water lifting specification advisory services and assembly/disassembly of pumps), inputs supply (spare parts, accessories, fuel and lubricant) and crop failure risk-reducing measures (pump renting and facilitation of shared ground insurance and serving to reciprocate agreement).

Table I: Changes in the provision of diversified pump support services and crop failure risk- reducing measures after the interventions

| Service type | MSP | FSP | Farmers |
|---|-----|-----|---------|
| Changes in diversified water lifting services | | | |
| MR | √ | √ | √ |
| Advisory | √ | √ | √ |
| Assembly/disassembly | √ | √ | √ |
| Inputs | √ | √ | √ |
| Crop failure risk-reducing measures | | | |
| Renting | √ | √ | √ |
| Group insurance | √ | √ | √ |

Key lessons and challenges

Diagnosis approaches using the irrigated crops commodity platform were found to be useful in identifying the gaps in frontline pump service providers (leveraging points) along the value chain development through participation of value chain actors and service providers. The gaps in frontline pump service provision were identified as key leveraging points in the development of irrigated crops value chains. To enable and establish the frontline pump service providers, appropriate selection of service providers was important for the success of the intervention. Interested farmers, preferably young, educated and with some knowledge and skills on pump operation and maintenance were selected to enable and establish WLS provision. Following the capacity development, the continuous follow up and cascading skills and knowledge through the establishment of strong linkages between the frontline (skill demanding) and mechanics (skill sources) were found to be a useful mechanism among the service providers. Moreover, the

diversified WLS services and crop failure risk-reducing measures enhanced the confidence of farmers to utilize the groundwater and surface water resources for the production of high-value irrigated crops that increased their income.

Implications for scaling out

The coverage of the introduced frontline WLS services providers expanded in both Tigray and SNNP. In Tigray, the number of intervention PAs with MSP coverage increased by 38% and that of FSP by 63% after the interventions. After the interventions, the WLS services also scaled out to the domain PAs (PAs outside the intended intervention PAs). The number of domain PAs with MSP increased by 83% and that of FSP by 56%. In a similar pattern, MSP beneficiary farmers increased by 45% and by 73% in the domain PAs after the interventions. Similarly, FSP beneficiary farmers increased by 45% in the intervention and by 93% in the domain PAs.

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Feeding hungry and thirsty soils increases yield and protects the environment: some results of a wetting front detectors (WFD) experiment in LIVES

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Introduction

To date, the majority of agricultural land in Ethiopia remains under low input/low output rainfed agriculture. These land units are highly susceptible to rainfall variability both in magnitude as well as occurrence (Mekonen and Kebede 2011). There are ongoing efforts to increase farmers' access to irrigation through schemes as well as individual smallholder systems (e.g. pumping) to sustain agricultural rainfed productivity while intensifying agriculture outside of the main rainy season. The Agricultural Transformation Agency estimates irrigable land potential at 11.4 million hectares (ha). As such, governmental programs such as the Agricultural Growth Program (AGP) I and II contribute strongly to ongoing development in small- and large-scale irrigation using both groundwater and surface water resources.

Sustainable irrigation development requires sound use of natural resources such as land and water. Efficient water use covers the water source, water storage, conveying water to the field and on-farm water management. For individual irrigators outside of a scheme, the farmer is often responsible for all of these aspects whereas in irrigation schemes, farmers depend on the operational structure and are mainly involved in water conveyance (together with water user associations) (Hailelassie et al. 2016c) and on-farm management. In gravitational schemes, the main challenges leading to inequitable distribution of water are water excess releases to compensate losses along the conveyance and delivery system (e.g. leakage and seepage losses) and inefficient on-farm water management practices. According to the diagnostic survey of Hailelassie et al. (2016b), on-farm water management in Ethiopia is relatively poor resulting in low yield and water productivity. In cases where farmers use motorized pumps to lift water (e.g. Ziway), farmers tend to over irrigate leading to high fuel costs and degradation of soils and water bodies as nutrients are leached and groundwater tables raised. Furthermore, over irrigation removes essential nutrients below the root zone leading to low fertilizer efficiency and low production. Guiding farmers in how much and when to irrigate requires easy tools that are robust in the field and simple to use as many farmers are still illiterate. Hence, complex scientific methods such as soil moisture based, crop water-requirement based etc. are often too expensive and complex for smallholder farmers to use as these methods require calculations, scientific knowledge and in many cases batteries. Therefore, within LIVES the WFD was selected as it is a mechanical device (i.e. no power or complex electronic wiring) and simple to use (i.e. no numbers or calculations needed).

Context

Koga reservoir (11°20' - 11°31' N; 37°02' to 37°08' E; 1,880 -2,020 metres above sea level (a.s.l.)), commissioned in 2010 and with a volume of 83 mm³, is one of the latest large scale irrigation schemes for smallholder farmers which, through its 1,750 ha reservoir, supplies irrigation to approximately 5,828 ha from a total of 7,000 ha in the dry season and more than 10,000 beneficiaries (Hailelassie et al. 2016b). The reservoir feeds 12 irrigation blocks between November and May. The command area has a total of 12 irrigation blocks and 11 night storage reservoirs. Secondary canals are fed by the main canal and night storage reservoirs and deliver water to the individual command areas via tertiary and quaternary canals. Each quaternary canal has two outlets supplying 30 m³ s⁻¹ irrigating a maximum of 16 ha

in total on a rotational basis of 8–10 days (i.e. approximately two ha per day). The irrigation rotation at the quaternary canals is dependent on the actual irrigated area of the cultivated crop within the season, with a maximum of two ha per day.

The irrigated area in the scheme starts with a low 700 ha in September to a maximum of 5,950 ha in December–February and decreases thereafter until June to 4,500 ha (Agide et al. 2016a). No water is released during the main rainy season (July–August). The average land holding size is 1.2 ha and furrow irrigation is common practice. During the irrigation season, wheat (*Triticum aestivum*) is the main crop (60 % of the cropping area) followed by potato (*Solanum tuberosum* L.) (15 %), onion (*Allium cepa* L.) (15 %) and maize (*Zea mays*) (10 %) (Hailelassie et al. 2016a). The main soil type (> 90%) in the command area is a Haplic Alisol while the remaining soils can be classified as Vertisols and Gleysols (Mekonen and Kebede 2011). The dominant soil texture within the scheme is silty clay.

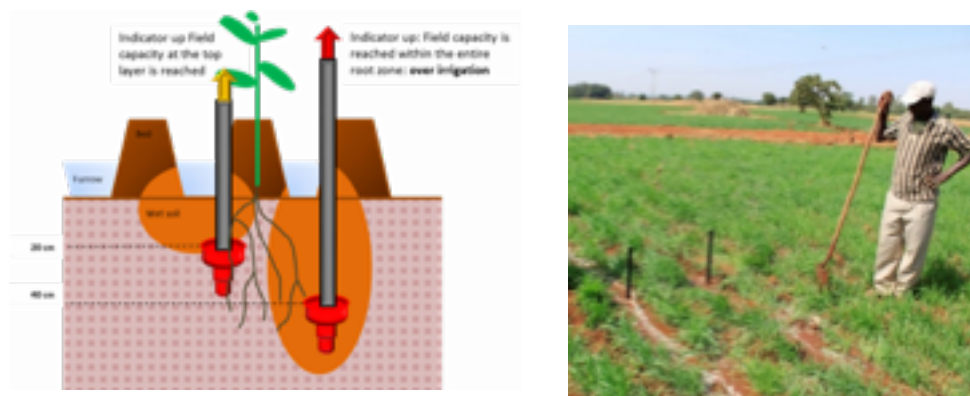
Irrigation in East Shoa has high potential due to the abundance of groundwater as well as surface water resources. The Meki scheme is fed by Lake Ziway and situated in Dugda district (08°07'N; 38°49'E; 1,880 - 1,650 m a.s.l.) (Hailelassie et al. 2016a) with a potential irrigable area of 3,000 ha with currently 700 beneficiaries (personal communication). However, as water is scarce within the scheme, many farmers use their private diesel pumps to extract water either from the Meki River or shallow wells instead of the scheme. The average land holding size is 2 ha and irrigated using furrows. Overall, farmers in this area are more experienced compared to Koga; furrows are well prepared and maintained and have a fixed average length of 5 m for all irrigated vegetable crops. During the irrigation season, the areal coverage of cabbage (*Brassica oleracea*), maize (*Zea mays*) and onion (*Allium cepa* L.) is 30% each of the total irrigated area (i.e. 700 ha) whereas tomato (*Solanum lycopersicum*) only covers 10% (Hailelassie et al. 2016a). There are four main soil types within Dugda district: Pelli-Calcic Vertisols (hilly areas), Vitric Andosols (rift valley floors), Gleyic-Mollic Fluvisols (lake shore of Lake Ziway) and Mollic Solonetz (bottomlands and depressions within the flood plains).

Description of the intervention: approach/technology

WFD⁶ are mechanical devices which, depending on the soil type, irrigation method and quantity, are installed in pairs at a specific depth below the soil surface (Stirzaker 2003; Stirzaker et al. 2004). When field capacity is reached and soils gravitationally start draining, the water is collected within the reservoir below the funnel. Depending on the amount of water collected in the reservoir (i.e. suction > 3kPa), the float will be activated. Each pair consists of a yellow and red indicator. For furrow irrigation, the yellow indicator is installed around 20 centimetres (cm) whereas the red indicator is installed around 40 cm below the soil surface. More detailed information on the functioning and installation of WFD can be found in Stirzaker et al. (2004). Farmers were trained on how to use the irrigation tool and instructed to start irrigation one day after the yellow indicator (shallow detector) stayed down and stop when the shallow detector responded.

⁶ The WFDs were invented by Richard Stirzaker at Commonwealth Scientific and Industrial Research Organisation (CSIRO) and produced in South Africa by Agriplas.

Figure 1: Installation of the WFD according to Stirzaker et al. (2004) (left) with a wheat farmer in the Koga irrigation scheme (right).



The tool was tested in Koga (gravitational) and Meki (pumping) irrigation schemes during the dry season of 2015–16 (Table 3) with 108 farmers. Action research was conducted on-farm to determine the: 1) effect of WFD on water and fuel saving in gravitational/pumping schemes, 2) use of WFD by IWUA and the impact on water saving, and area expansion and 3) combined effect of WFD and recommended fertilizer on crop and water productivity. To assess the effect of different fertilizers, the recommended fertilizer treatment applied 150 kilograms (kg) ha⁻¹ of urea at planting and 200 kg ha⁻¹ of NPS (18-37-7); the farmer practice applied on average 360 kg ha⁻¹ of DAP and 150 kg ha⁻¹ of urea.

At all sites, graduate students as well as research staff collected information on traditional irrigation practices, field characteristics (furrow length, soil type, discharge), agronomic crop performance (plant height, marketable and unmarketable yield, plant mortality, fruit size), time and quantity of irrigation, farmers perception of the WFD and the yield obtained.

Table 1: Overview of the various WFD experiments performed during 2015–16 at the LIVES sites

| Site | Experiment | Crop | Period | Irrigation | Number of farmers |
|------|--|-------|---------|----------------|-------------------|
| Koga | WFD and recommended fertilizer (NPS) vs. farmer practice | Onion | 2015–16 | Scheme | 26 |
| Koga | IWUA use WFD | Onion | 2015–16 | Scheme | 56 |
| Meki | WFD vs. farmer-controlled irrigation | Onion | 2015–16 | Motorized pump | 22 |

Results

When looking at optimal fertilizer usage, the recommendation of NPS and urea aside from the usual urea and DAP usage could further positively influence crop yields and economic benefit (Table 2). For onion, the use of WFD significantly increased onion yield from 26.4 tonnes (t) ha⁻¹ to 28.7 t ha⁻¹ while reducing water application by 18.5%. When the fertilizer application was additionally optimized aside from introducing the WFD, the 26.4 t ha⁻¹ yield increased to 29.7 t ha⁻¹. Accounting for the average cost of urea, DAP and NPS as well as the onion market price, a gain of 1,153 US dollars (USD) per ha could be achieved in the plots where farmers combined the WFD with the recommended fertilizer. Not only was the amount of fertilizer reduced but when looking at the implications of potential leaching, a 20% reduction of nitrogen (N) and 50% reduction of phosphorous (P) was achieved during the cropping season. This reduction together with a more optimal water supply could lead to decreased leaching of N

and P in irrigation systems. Hence, saving water will not only reduce potential water conflicts, increase yield and water productivity in schemes but will also enhance ecological flows.

Table 2: Profit based on onion yield obtained from the control and WFD plots using the farmers practice or recommended fertilizer (NPS) application in 2015–16 in Koga (onion: USD 0.31/kg, USD 1 = ETB22)

| | | Price (USD/kg) | Fertilizer farmers practice (kg/ha) | Fertilizer recommended (kg/ha) | Profit WFD and NPS (USD) |
|------------------------|----------------|----------------|-------------------------------------|--------------------------------|--------------------------|
| Fertilizer | Urea | 0.5 | 150 | 150 | 0 |
| | NPS | 0.7 | - | 200 | -140 |
| | DAP | 0.7 | 362 | - | 253 |
| | Subtotal (USD) | | - | 113 | 113 |
| Yield | WM-Control* | | 26,400 | 27,600 | |
| | WM-WFD* | | 28,700 | 29,700 | 1,040 |
| | Subtotal (USD) | | 724 | 674 | 1,040 |
| Total profit WFD (USD) | | | 724 | 787 | 1,153 |

*WM means water management in the plot with control referring to farmers practice.

One of the many direct and indirect benefits of saving water related to motor pumping is lower pumping cost, longer lifetime of the pump and less maintenance or repair costs. Based on the obtained preliminary results, 2,338 m³ was saved in Meki. Depending on the head, the estimated pump discharges were 0.0041 m³ s⁻¹ for groundwater extraction, 0.0066 m³ s⁻¹ when pumping from the lake and 0.0101 m³ s⁻¹ if water was extracted from the river. This would result in a pump saving of 36 h (river), 54 h (lake) and 88 h (groundwater) per ha. Using an average fuel consumption of 1.5 litre per pump for one ha, this would result in a reduced consumption of 54 l, 81 l, and 132 l or an economic gain of USD63, USD97 and USD156 ha⁻¹, respectively.

When looking at irrigation schemes and onion production in Koga, results showed that significant volumes are saved at quaternary outlets as well as block level for the tested areas in Tagel, Chihona and Adibera. Six IWUA were trained under LIVES on how to irrigate land using information from WFD installed in a single farmer's field. For one entire irrigation season, farmers managed the irrigation of onion in their block by using information from a few installed WFD. On average, every 0.5 ha was managed by the information of one WFD with on average each IWUA managing between 1 to 1.5 ha at their quaternary outlet. Due to a water shortage in 2016, the reservoir supplied water to irrigate 3,572 ha which is only 51% of the total command area. The total irrigated land encompassed 200 ha for onions, 2,576 ha for wheat, 123 ha for barley, 22 ha for maize, 495 ha for potato, 90 ha for cabbage, 39 ha for tomato, 13 ha for pulses and 13 ha for chilli. The water saved could supply water to an additional 37% of the cultivated land for onion (i.e. 74 ha), resulting in a total of 274 ha for onion production. Even larger results were found for potato where the saved water could irrigate an additional 422 ha on top of the 495 ha cultivated land resulting in a total of 917 ha.

Currently, the Ethiopian Institute for Agricultural Research (EIAR) and several other national partners have shown interest in scaling out WFD trials, tailoring the research to the needs of small-scale irrigators. Through LIVES, IWMI is supporting the installation, training in operation and data collection to increase the number of test beds and to provide sufficient support for irrigation guidelines of the various irrigated commodities in the country.

Key lessons and challenges

The success of the implementation of WFD strongly depends on the participatory approach followed during implementation. Real on-farm field trials with farmers provide valuable insights on outcomes of the WFD as an irrigation learning tool and the environmental, economic and agronomic impact. However, external factors such as water shortage in the schemes, dropping of market prices or overall water shortage, such as in 2015–16, have

influenced the number of targeted farmers. Furthermore, on-farm trials are challenging when it requires similar management and cropping practices. Hence, some of the farmers might deviate from the requested practices, increasing variability within some treatment groups.

Implications for scaling out

While WFD is a great learning tool for both researchers and farmers, we need to think beyond the physical expansion of the tool during scaling out and focus on what it means in terms of tailoring irrigation scheduling advice for farmers as well as changing some of the more 'traditional' training materials and methods used in irrigation capacity development activities. WFD require a novel approach for trainers and trainees, using visual aids and temporary instalments rather than seeing it as a tool that is fixed in a field until the end of its lifespan.

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LIVES feed value chain development: approaches and scalable interventions

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ILRI

Introduction

Feed is the single most important factor constraining the productivity and market potential of smallholder livestock in Ethiopia. Grazing accounts for 58% of the total livestock feed demand and is followed by a 30% contribution from crop residues (CSA 2012/2013). According to recent regional feed surveys carried out by LIVES, only 60–80% of the annual maintenance requirement of livestock in the four regions where LIVES operates is met. This is despite the need to secure year-round feed supplies to meet targets set for meat (58%), milk (83%) and eggs (240%) production increases by 2020 (ELMP 2015). A LIVES baseline study in 2014 revealed that access to commercial concentrate and ingredients such as wheat bran and oil seed cakes is low mainly due to lack of attention to linkage facilitation.

Context

LIVES carried out key feed development/improvement and linkage facilitation in Amhara (North Gondar, South Wollo and West Gojjam Zones), Oromia (Jimma, East Showa and West Showa Zones), SNNP (Sidama and Gamo Gofa Zones) and Tigray (Central and Eastern Zones) Regions. In the 10 zones, there are more than 20 million people (CSA 1999). These zones also account for 30% of cattle and sheep, 23% of goats, 33% of poultry and 28% of beehive populations of the country (CSA 2012/2013).

The specific scalable feed development interventions were: 1) improving the productivity of grazing lands, 2) improved green fodder production, 3) fibrous feed improvement and preservation and 4) facilitating linkages between feed traders and producers.

LIVES carried out zonal workshops with stakeholders, validated clustering of districts and PAs with district staff, and recruited intervention households. District-level livestock commodity platforms were formed and members identified and prioritized the challenges/constraints of high-value livestock commodities. Selected intervention households participated in LIVES capacity development and knowledge management events and received demonstration materials; they also benefited from house-to-house coaching and mentoring services. Feed traders were included in LIVES linkage facilitation interventions.

Description of the intervention: approach/technology

In Oromia, grazing land improvement methods included urea/DAP mixes (150 and 100 kg/ha), manure (7.5 t/ha), and wood ash (3 t/ha). Dried manure was left to decompose for three months and dissolved in water. In Tigray, only urea was applied at 100, 150 and 200 kg/ha rates.

Improved fodder production was integrated with existing small-scale irrigation and planted as pure stand, along canals, riverbeds and sloped areas. Only the most productive species were targeted: alfalfa, desho, Napier, and Rhodes. For bee fodder, attention was given to fast growing and pollen and nectar-rich dwarf shrubs.

Chopper, essential microorganisms (EM), urea, molasses and plastic tubes were used to improve the nutritional quality of fibrous feeds. EM treatment followed the guideline provided by the supplier (Waljaji Agricultural Development PLC in Bishoftu). For EM-treated straws and stovers, the treatment duration was only 24 hours while for bokashi and silage, the duration lasted three weeks.

Results

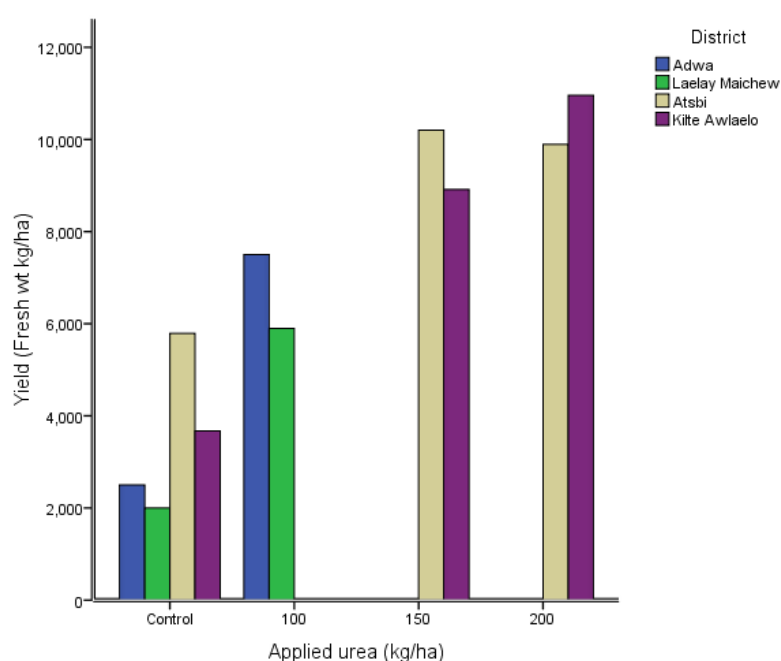
Table I shows that in the Oromia Region, the addition of nutrients in the form of ash, cow dung and chemical fertilizers increased total biomass production compared to the control (5,743 vs. 2,829 kg dry matter (DM)/ha).

Table I: Biomass yield of fertilized and control grazing plots in Oromia Region

| Treatments | Total biomass |
|--------------|---------------|
| Control | 2,829.3 |
| Ash | 3,944.0 |
| Urea and DAP | 5,742.9 |
| Manure | 4,702.7 |

In Tigray Region, urea top dressing led to yield increments ranging from twofold to threefold over the control (Figure I). Cutting frequencies tripled compared to unfertilized control plots and fertilizer application also extended the period of greenness by one to two months. In both regions, the technology is increasingly being adopted by individual farmers and grazing committees.

Figure I: Biomass yield from urea top-dressed grazing lands in Tigray Region.



Picture 1: Urea top-dressed grazing land in Adwa (left) and Saesi Tsaeda Emba (middle) and farmers participating in a 'Pasture Walk Day'.



For most LIVES intervention districts, improved green fodder production is relatively new and farmers took advantage of the current scarcity in forage planting materials and quickly adopted the technology. LIVES-improved fodder production served as a reliable seed source for others.

In Oromia, desho, Napier and Rhodes grasses were demonstrated to farmers and FTCs by providing planting materials to selected intervention households and FTCs. Desho grass in particular was favoured by farmers who generated up to ETB30,000 from selling splits. Farmers witnessed an increase in the amount of milk yield and improvement in the quality of butter.

In Amhara Region, 287 producers and FTCs benefited from improved green fodder production. Farmers in Mecha district produced Rhodes grass seeds and generated ETB450,000–600,000. Others also benefited from producing splits from bracheria and desho species, alfalfa and white clover seeds (Table 2).

Table 2: Farmers preference rank on four major irrigated fodder crops in Amhara Region

| Fodder crop | Harvesting interval | Yield | Preference by animals | Harvesting frequency |
|----------------|--|-------|-----------------------|----------------------|
| Elephant grass | In 21 and 30 days during dry and wet seasons, respectively | 2nd | 1st | 1st |
| Rhodes grass | In 45 days during wet season | 4th | 3rd | 3rd |
| Desho grass | In 60 days both in dry and wet seasons | 3rd | 2nd | 2nd |
| Bracheria | In 60 days both in dry and wet seasons | 1st | 4th | 2nd |

In Tigray Region, about 151 farmers grew alfalfa and Napier grass. The average land allocated for growing alfalfa is 321 m², the average fresh biomass yield is 3 kg/m² and the average cutting interval is 21 days. Through time, farmers developed the skill of managing alfalfa fields. Perceived benefits included up to 50% increase in milk yield from crossbred cows and reduced purchased-feed costs. Napier grass was planted along erosion prone-river beds and sloped areas. Similarly, seedlings of *Becium grandiflorum* (tebeb) were planted by beekeepers which increased nectar flow, improved colony strength and yielded 3–5 kg/hive honey.

Picture 2: Farmer-managed pure alfalfa field (left two), alfalfa mixed with maize (middle) and guava fruits (right).



Picture 3: Napier grass in Amhara and Tigray regions.



Current practices on the use of crop residues/stover involve large wastage. LIVES demonstrated the use of manageable size choppers in combination with EM.

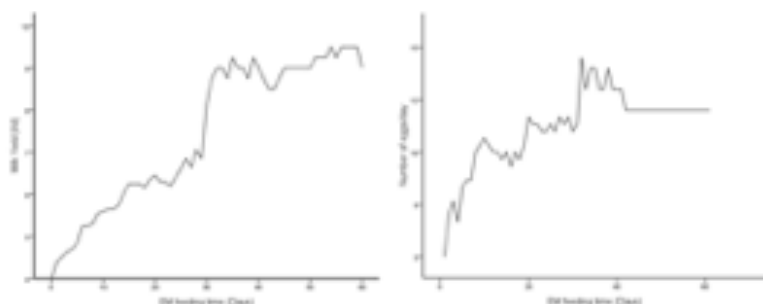
Picture 4: Traditional maize stover handling practice (left), chopper businesses in Amhara (middle) and Tigray (right).



Chopping and treating of stover with EM increased feed intake, improved feed utilization, and minimized wastage. A huge demand has been created following demonstration of the technology and individual farmers and dairy cooperatives have purchased the machine. Similar prototypes were made in Amhara and Tigray Regions.

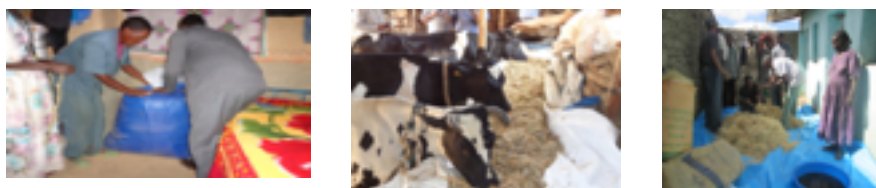
In Amhara, Ormoia and Tigray Regions, dairy farmers and fatteners who used EM-treated teff straw witnessed up to 2–3 kg improvement in intake/day, 0.5–1.5 litres increase in milk yield, and a shorter cattle finishing period. In Tigray Region, average milk yield doubled and feeding poultry EM-treated wheat bran led to a 40–50% increase in egg production (Figure 2), reduction in ammonia gas smell and recovery of leg-paralysed birds. In Oromia Region, farmers reported a more than 20% increase in egg production and fast growth of chickens. The EM technology was adopted by more than 500 households in Oromia and Tigray Regions.

Figure 2: Milk and egg production trend after feeding EM-treated straw and wheat bran in Tigray region.



Plastic bag technologies (Picture 5) were used for silage making and urea/molasses treatment of crop residues.

Picture 5: Storage of plastic silage by a farmer (left), dairy cows feeding silage (middle) and urea- treated teff straw (right) in Tigray Region.



In Amhara, Oromia, SNNP and Tigray Regions, 32 feed shops were able to trade more than 31,000 quintals of AIBPs and generate more than ETB19 million gross revenue (Table 3). A case from Amhara Region showed that such support can reduce feed cost by 36%.

Table 3: Feed shops and their performance in LIVES intervention regions

| Region | Number of shops supported | Amount sold (quintals) | Gross revenue generated (ETB) | Remarks |
|--------|---------------------------|------------------------|-------------------------------|-------------------------------|
| Amhara | 5 | - | - | - |
| Oromia | 4 | 1,515 | 1,063,960 | From two shops over one year |
| SNNP | 6 | 10,084 | 8,067,200 | From six shops over two years |
| Tigray | 17 | 19,736 | 10,533,289 | From 17 shops over one year |
| Total | 32 | 31,335 | 19,664,449 | |

Key lessons and challenges

The possibility of increasing the productivity of grazing lands using fertilizers is promising. Application of fertilizer to grazing lands requires convincing grazing committees and local leaders.

Improved green feed development can easily be integrated with existing irrigation systems. Preparing easy-to-read small booklets is helpful. Certified forage seed supply system remains a challenge. Supporting farmer-to-farmer seed exchange can serve as a short-term solution and in the long term, engaging national agricultural research institutes (NARS)/universities in forage seed production is needed.

Bee fodder development is an attractive incentive for beekeepers and requires less effort and investment and needs to be embedded into the annual work plan of public nurseries.

Chopping coarse feeds increases intake and addition of EM to chopped feeds optimizes its palatability and edibility. Access to choppers and big-size plastic sheets, however, was a challenge for most farmers.

Loose feed quality certification/regulation and lack of focus on facilitating linkage with input suppliers is a challenge and there is a need to revisit current extension support.

Implications for scaling out

Fertilizer applications need to be applied on areas where grazing contributes a substantial proportion of the annual livestock feed demand and where cut-and-carry system is practised.

Green feed development can attract farmers who are closely associated with dairy farming linked with market.

The use of choppers needs to be a priority in irrigated areas where the availability of stover and other coarse green feeds are abundant. Linking chopper service with cooperatives/unions and youth groups can be an effective option. Silage and urea treatment using plastic bags needs to target farmers with a small number of animals.

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LIVES poultry value chain development interventions: approaches and scalable interventions

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ILRI

Introduction

Increase in poultry meat and egg production is one of the top focus areas in the Growth and Transformation Program (GTP II) of the Ethiopian government in response to the possible increase in meat and egg demand resulting from an increase in human population, increased income and urbanization. Furthermore, the increase in poultry as a protein source is related to Climate Resilient Green Economy (CRGE) because chickens are low emitters of greenhouse gases (Shapiro et al. 2015). Poultry production has the potential to lift poor communities out of poverty; poor people benefit greatly from livestock ownership, especially small livestock like poultry. This is particularly true for women and youth who have limited options for other income-generating activities. Despite such potential, current poultry productivity is disproportionately low due mainly to poor feeding.

Current poultry feeding practices largely rely on the use of unbalanced local food grains without considering the need to provide balanced nutrition for the different classes of poultry. Use of formulated commercial feeds is hindered by lack of access for most chicken producers in terms of availability in the local markets and the high cost of formulated rations where feed accounts for about 70% of the total cost of poultry farming. In some instances, the use of formulated commercial feeds for the different classes of chickens is hindered by a lack of awareness among semi-commercial poultry keepers who can afford to use commercial feeds. Thus, improving the poultry feeding system requires different approaches for different situations.

While chicken rearing is transforming from free range to indoor, eggs produced from indoor chickens lack the deep yellow yolk colour preferred by Ethiopian consumers, which affects demand and price. Other challenges to the poultry value chain development are the shortage in the supply of day-old chicks (DOC)/pullet/layers, improper housing and biosecurity measures, and the lack and/or weak linkages to input/service providers and market systems.

Thus, different interventions were undertaken to tackle these problems in LIVES intervention areas of Oromia, Amhara, Tigray and SNNP. The interventions focused on ration formulation using locally available feed resources, treatment of feeds with effective microorganism (EM bokashi), introduction of commercial formulated ration, alfalfa-based poultry feeding, small-scale DOC supply system, improved housing and biosecurity measures, debeaking service provision, and linkages to input/services and markets.

Context

The action research was undertaken in LIVES intervention zones and districts of Oromia Region (East Shoa, and Jimma Zones), Amhara Region (West Gojjam and North Gondar), Tigray Region (Central and Eastern Zones) and SNNP (Sidama and Gumugofa Zones) which represent diverse agro-ecologies and agricultural production systems.

Description of the intervention: approach/technology

The approaches followed or the technologies used for each intervention are described below:

Ration formulation using locally available feed resources

The interventions included: 1) replacement of soyabean meal with locally available fish meal in balanced poultry rations and 2) ration formulation and balanced feed supply businesses in district towns using locally available feed resources. Both problems were identified in stakeholders' platform meetings where the lack of quality poultry feed supply was identified as a major problem. Action research generated the evidence required for the first activity. For the second activity, the approaches followed included skills training such as hands-on practice and computerized feed formulation software for ration formulation, study tours for participating farmers and feed formulators, and linkages created between feed processors and farmers. Farmers and feed formulators were continuously coached and mentored.

Treatment of feeds with EM bokashi

EM bokashi for layers is prepared by mixing extended EM, molasses, water and wheat bran. EM is imported by Waljaji Agricultural Development PLC (Bishoftu, Ethiopia). It is formulated at Bishoftu and Adama and the formulated EM is also available in different regional towns. A litre of EM costs ETB25. The evidence on the effect of EM treatment of feed was generated from three intervention households in Tigray who own 5–18 Koekoeck breed layers. The feeding occurred from 30–60 days during which feed offered and refused, and numbers of eggs laid were recorded by the farm owners. Training on EM-bokashi preparation skill was provided to farmers, linkages were created between farmers and sources of technologies (e.g. EM suppliers), and intervention farmers were coached and mentored.

Introduction of commercial formulated ration

The intervention involved introducing commercial rations specifically formulated for different classes of poultry (starter, grower, layer and broiler rations) and targeted semi-commercial small to medium-scale peri-urban/urban farms. In the approach, the intervention was introduced following awareness creation through study tours to modern farms using commercial rations formulated for the different classes of poultry. Training on improved chicken feeding was also provided. Poultry keepers were then linked to commercial feed shops organized by the LIVES project in district towns or existing feed suppliers. Furthermore, two action research activities were conducted in Oromia and Tigray Regions to see the impact of introducing commercial concentrate feeding on egg production. In the Oromia action research, forty women chicken producers (from three PAs in Kersa district, Jimma Zone) each having five Bovan brown pullets were provided with pullet and layers rations supplied by Alema Koudijs Feed PLC.

Alfalfa-based poultry feeding

Alfalfa-based poultry feeding consists of backyard alfalfa production and feeding. Green leafy alfalfa is hung throughout the chicken house so that chickens can peck the leaves at ease, diverting attention from pecking each other. Training and alfalfa seeds for demonstration were provided to farmers.

Small-scale DOC supply system

LIVES in the Tigray Region organized training on small-scale hatchery skills and management, organized DOC growers in collaboration with regional livestock research institutes and bureaus of livestock and fisheries, introduced new mini-

hatcheries and coached and mentored intervention groups. To introduce the intervention, LIVES worked with eight DOC growers.

- 1) Small-scale hatcheries: The major intervention was to establish local small-scale hatcheries which can be owned by individual entrepreneurs or groups. Commonly, women groups were preferred.
- 2) Mini-incubators: LIVES introduced Hova-Bator mini-incubators with a capacity of 42 eggs. The technology can be introduced for poultry producers' own use in groups or through small DOC supply businesses operated by women/youth groups.
- 3) Linkage support: The small-scale hatchery groups or private entrepreneurs need to be linked to sources of fertile eggs, incubators, improved rations and credit services.

Improved housing and biosecurity measures

The approach to introduce the interventions included awareness creation, training, demonstration of biosafety equipment, study tours to exemplary farms, creation of linkages for different inputs, and coaching and mentoring of farmers, extension staff and other value chain actors. The subactivities of the intervention were:

- 1) Improved and hygienic housing package: LIVES introduced and demonstrated an improved poultry housing package. The package included two types of 4- and 5-tier cage housing systems suitable to peri-urban and urban poultry production settings, and a locally designed and manufactured poultry house for the rural system with hygienic watering and feeding equipment.
- 2) Biosecurity measures: The major component of biosecurity measures included introduction of foot bath, regulations on biosecurity measures and general house cleanliness.

Linkages to inputs/services and markets

The intervention involved linking producers to sources of poultry production inputs (e.g. DOC, pullets, commercial feeds, modern equipment) and services, and to profitable markets by shortening the long value chain to increase producers' profit margin. Study tours to markets and improved poultry farms facilitated linkage creation with egg and feed traders.

Debeaking

The service providers which were identified by the LIVES project in Bahir Dar were linked with indoor poultry farmers in North Gondar and West Gojjam Zones. In addition to creating jobs for individual/groups, debeaking improves the productivity of poultry farms. This technology is not appropriate for scavenging chickens.

Results

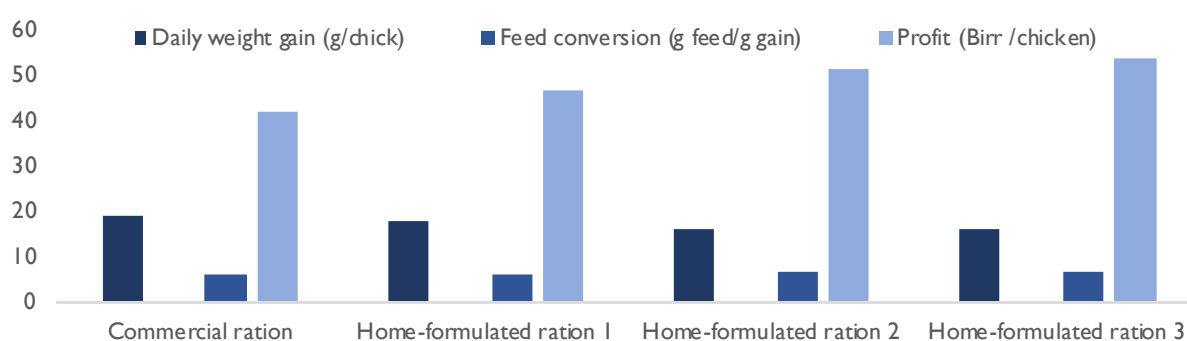
Fish meal-based ration formulation using locally available feed resources

Three home-formulated rations consisting of partially replacing soyabean meal with fish meal were compared with Alema Feed Company commercial rations using dual purpose growing chickens (Koekoek breed) in the LIVES intervention district of Dugda (East Shoa Zone). The coarse feed ingredients were first ground and mixed using a feed chopper. The rations are shown in Table 1. Chicks fed the commercial ration (R1) gained weight faster and required less feed per gram of weight gain than all three of the home-formulated rations (Figure 1). However, the home-formulated rations, especially ration 2 (R2) were found to be best biologically and economically. Five extension staff (four males and one female) and 10 poultry producers (two females and eight males) from peri-urban and rural areas of Dugda district visited the action research sites and discussed its application and future direction on poultry feeding. In addition, an investor is establishing a fish meal processing plant at Bote (Alemtena).

Table 1: Percentage of feed ingredients in commercial Alema Koudijs commercial ration and home-formulated rations

| Ingredients | R1 (Alema commercial feed) | R2 (Home formulated) | R3 (Home formulated) | R4 (Home formulated) |
|----------------------|----------------------------|----------------------|----------------------|----------------------|
| Maize | 51.60 | 52.00 | 52.00 | 52.00 |
| Soyabean meal | 15.00 | 10.00 | 5.00 | 0 |
| Wheat bran | 16.00 | 26.00 | 26.00 | 26.00 |
| Fish meal | 5.00 | 10.00 | 15.00 | 20.00 |
| Limestone | 1.00 | 1.00 | 1.00 | 1.00 |
| Nouge cake | 10.00 | - | - | - |
| Methionine | 0.10 | - | - | - |
| Premix | 1.00 | - | - | - |
| Salt | 0.30 | 1.00 | 1.00 | 1.00 |
| Total (%) | 100.00 | 100.00 | 100.00 | 100.00 |
| Energy content | 3,225.89 | 3,226.80 | 3,193.50 | 3,160.10 |
| Protein content | 19.87 | 19.80 | 21.43 | 22.97 |

Figure 1: Daily weight gain and feed conversion efficiency of chicks supplemented with commercial and home-formulated rations and profitability of the rations.



Locally formulated feed supply

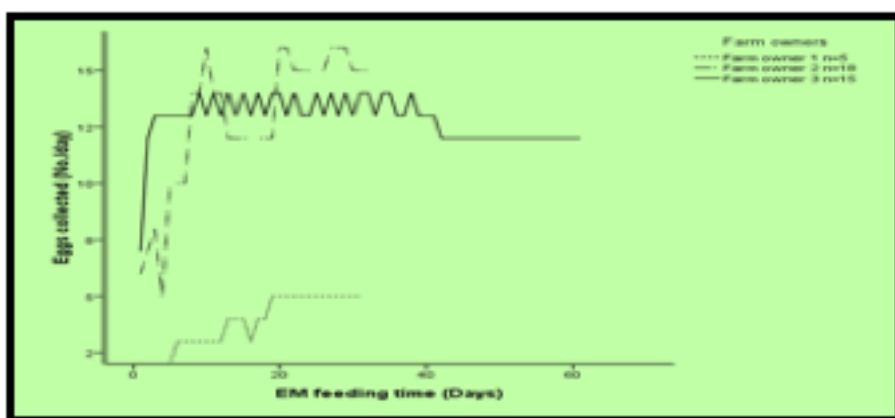
Most of the trainees (West Gojjam and North Gondar) started formulating feed for their own farm after receiving training. Three of the trainees came out as strong poultry feed processors (one in Bahir Dar and two in Gondar). These three are now acting as model poultry-feed suppliers in West Gojjam and North Gondar. One poultry farmer at Bahir Dar has started supplying fish meal to governmental and nongovernmental organizations (NGOs) in addition to preparing a balanced ration. Recently, he won a large grant from an NGO to expand fish meal preparation on a larger scale. Individuals who received training and started processing formulated poultry rations are earning a significant amount of income. Furthermore, they assisted smallholder poultry farmers by providing poultry feed at a reasonable cost in local markets. For instance, one individual sells a quintal of formulated poultry feed at ETB600 whereas the cost of a quintal of poultry feed from Alema Koudijs including transportation cost from Addis Ababa to Bahir Dar is about ETB1,100. Producing poultry feed at the local level reduced the cost of feed by 36.4%. This has encouraged many farmers and urban dwellers to engage in poultry farming as a result of availability of formulated poultry feed in their locality at an affordable price. Furthermore, establishing feed processing businesses in the region has created job opportunities for many people in feed processing units and retail feed businesses.

Treatment of feeds with EM bokashi

The results of the action research in Tigray (Figure 2) demonstrated that the percentage of hens laying egg increased to 100% in the intervention households with five layers. In the other two households with 18 and 15 birds, the increase in egg production was 89% and 93%, respectively. Apart from egg production, producers also witnessed a significant reduction in ammonia gas smell and recovery of birds which were suffering from leg paralysis before the intervention.

In Oromia, the number of farmers adopting the technology was very high. In an observation in four PAs (Malima berie, Barta sami, Dodo Wadera and Tuji Deko) in Bora district and two PAs (Shera debandba and Jugo Gudeddo) in Lume district, it was found that 146 male and 67 female intervention and nonintervention farmers bought 553 litres of EM for poultry feeding. Farmers who used the technology reported an approximately 20% increase in egg production when fed EM-treated wheat bran compared to feeding with untreated wheat bran. A female farmer from Lume reported that her hens laid eggs every day after feeding EM-treated bokashi compared to laying every other day before the intervention. A young farmer from Lume reported that his hens laid 20% more eggs when fed EM-treated bokashi. It was also noted by farmers that usage in excess of that recommended in the brochure resulted in a decline in egg production. (The quantity of EM-treated wheat bran to be given to layers is a maximum of 2% of the daily ration requirement while it is a maximum of 5% in broilers.) Farmers also reported fast growth of chickens (increase in body weight), faster growth of the feathers and increased feed intake when fed EM bokashi. The technology is widely utilized, particularly in Bora district.

Figure 2: Egg production increases after feeding EM-treated feed in Tigray action research.



Introduction of commercial formulated ration

In Oromia, pullets were fed on average 100 gm/head/day and egg production monitored for 30 days. Layer ration had a highly significant impact on egg production (Table 2). The average percentage of hens laying eggs daily was 48.6%, whereas none of the nonsupplemented hens laid daily. The majority (85.5%) of the nonsupplemented hens produced less than 20 eggs in one month. Supplementation significantly reduced mortality (Table 3).

Table 2: Egg production performance of chickens supplemented or not supplemented with commercial layer ration in intervention PAs in Oromia

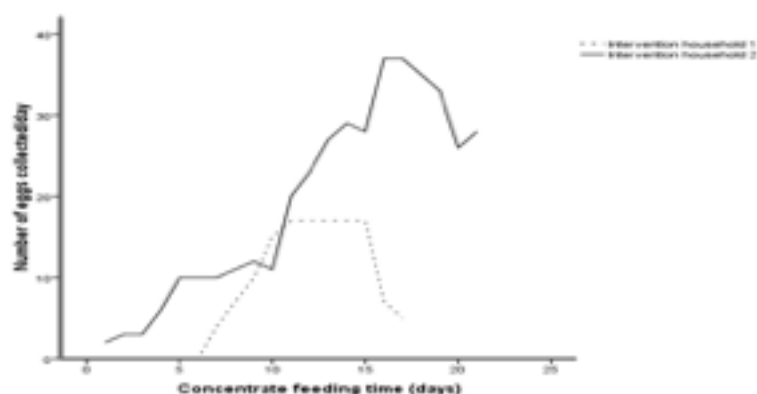
| Location (PA) | Supplementary feeding | Number of hens | Egg production in one month (% of hens laying) | | |
|---------------|-----------------------|----------------|--|------------|-----------|
| | | | 30 eggs | 20–25 eggs | < 20 eggs |
| Kitimble | Supplemented | 60 | 70.0% | 15.0% | 15.0% |
| | Not supplemented | 43 | 0.0% | 23.3% | 76.7% |
| Gello | Supplemented | 60 | 50.0% | 36.7% | 13.3% |
| | Not supplemented | 57 | 0.0% | 10.5% | 89.5% |
| Bulbul | Supplemented | 55 | 23.6% | 49.1% | 27.3% |
| | Not supplemented | 46 | 0.0% | 8.7% | 91.3% |
| Overall | Supplemented | 175 | 48.6% | 33.1% | 18.5% |
| | Not supplemented | 146 | 0.0% | 13.7% | 85.8% |

Table 3: Mortality of chickens supplemented or not supplemented with commercial layer ration in intervention PAs in Oromia of Kersa district, Jimma zone

| Location (PA) | Supplementary feeding | Mortality (%) | Remarks |
|---------------|-----------------------|---------------|---|
| Kitimble | Supplemented | 41.7 | Most died after feed ran out |
| | Not supplemented | 76.7 | Five died before laying |
| Gello | Supplemented | 56.7 | Most died after feed ran out |
| | Not supplemented | 70.2 | Four killed by predators, two were sold |
| Bulbul | Supplemented | 63.6 | Most died after feed ran out |
| | Not supplemented | 56.5 | 13 died before laying, eight soon after arrival |
| Overall | Supplemented | 54.0 | |
| | Not supplemented | 67.8 | |

Figure 3 shows the trend in egg production observed from two poultry farms, each with 50 birds, after introducing and demonstrating commercial layer rations in the central zone of Tigray.

Figure 3: Egg production trends in smallholder poultry farms adopting commercial layer ration in central Tigray.



Alfalfa-based poultry feeding

A consumer trend was to pay more for eggs produced from local chickens even though the eggs were smaller compared to exotic breeds because of a consumer preference for a deep yellow yolk. This trend is abating in LIVES intervention areas like Bahir Dar and Gondar as a result of the introduction of green alfalfa which improves egg yolk colouration. In addition, smallholder poultry farms which adopt backyard alfalfa for poultry feeding reduce flock cannibalism.

Small-scale DOC supply system

The mini-incubator introduced by LIVES was evaluated by Rahwa Poultry Association (an eight-women group in Enticho, Tigray Region) compared to their old 800-egg capacity incubator. The high-capacity incubator was infrequently used due to large power requirements and frequent power outages. Hatchability increased from 48% (with a maximum of 55%) with the high-capacity incubator to 83% with the new incubator. Eight DOC growers who worked with the LIVES project were able to market more than 140,000 chicks over the period 2014–15 and 2015–16. This approach benefited 6,326 poultry farmers (2,874 males and 3,452 females) in the region.

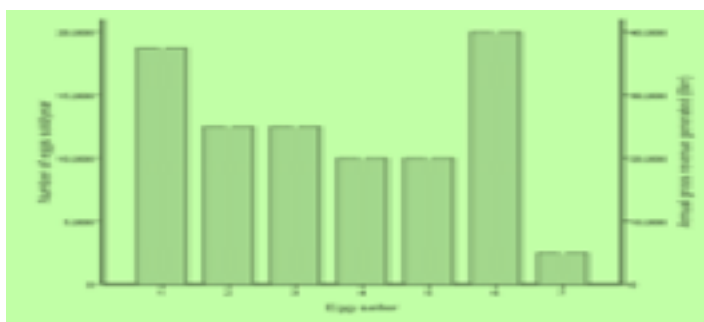
Improved housing and biosecurity measures

Households who participated in the demonstration expressed that the interventions have helped them to reduce flock mortality and morbidity, increase their flock size and ease management of their flocks. The interventions were well-adopted by poultry keepers. For instance, in two PAs in Bora and one PA in Lume districts, 306 male and 68 female poultry keepers adopted the interventions and bought improved drinking and feeding equipment and antibiotics. Two farmers from Abo Gabriel PA, Dugda district, bought improved poultry houses and a female farmer of Kersa district, Gello PA constructed poultry housing from local materials.

Linkages to inputs/services and markets

In Tigray, LIVES trained seven women in egg handling, business skills and marketing, and linked them with cafés, hotels and consumers (Figure 4). Assuming an effective 25 weeks of egg buying and selling, the total transaction of such market actors within this period ranged from 63,000 to 86,000 eggs. At an average selling price of ETB2 per egg, the gross revenue generated by such businesses could range from ETB1.3 to 1.7 million. A study tour was organized for women and men poultry groups to large poultry farms in Mekelle. The intervention has increased the skill and business potential of poultry and the participants created linkages with other egg and feed traders.

Figure 4: Women's group and their egg business in Tigray.



A linkage case story from Oromia

Obbo Dadi Leta and his spouse Basaha are LIVES intervention farmers in Meki, kebele 02 in Dugda district, Oromia Region. They started poultry keeping in 2015–16 after the Dugda district livestock and fishery resources development and LIVES intervention through couples training which paved the way for creation of appropriate linkages with input

suppliers. The couple training approach promoted equal participation in their poultry farm. The couple and other farmers were trained on house construction, chick/pullet/layer/broiler management, improved feeders and watering equipment, and brooders. They were linked to commercial feed shops in Meki established with the assistance of LIVES, DOC suppliers, chicken equipment and other inputs, and introduced to vaccine producers and vaccine application, all in Debrezeit. The couples were then coached by the kebele development agent (DA) and district extension staff who participated in the training and study tour. The DA and the extension carried out snap market survey on demand for eggs in Meki to establish market linkages. The couple soon received more requests for eggs than they were able to supply owing to the high quality of the eggs from their farm. They started with 307 layers. The financial analysis indicates that the farm generated a revenue of ETB202,620 from the sale of eggs and ETB26,280 from the sale of culled layers after 13 months of production. The couple spent ETB29,472 on the purchase of pullets, ETB112,608 for feed, ETB3,000 for medicine and services, ETB32,400. Thus, the gross margin in 13 months was estimated to be ETB51,420.

Figure 5: The couple enjoying their business



Debeaking

Smallholder poultry farmers who received the debeaking service reflected that it is affordable and significantly minimizes chicken cannibalism on their farm. Besides reducing cannibalism among birds, it reduces wastage of feed by minimizing selective feeding. Debeaking also minimizes incidence of egg breakage by hens. Ato Kassahun, one of the debeaking machine owners, debeaked about 20,000 chickens in 2015. The service charge for debeaking is ETB1.50 per chicken when the number of chickens to be debeaked is more than 500 and ETB2.00 per chicken when the total number of chickens to be debeaked is less than 500. Another machine owner, Ato Andargie, reported that he debeaked about 4,000 birds in a five months period for a service charge of ETB1.50 per bird.

Key lessons and challenges

The key lessons learned are the importance of using and the need to process fish meal. Regulatory mechanisms on the quality of feed resources and credit provision to input suppliers are important. Further action research is required on ration formulation from locally available feed resources for production systems that are far from the commercial feed supply. Additional effort is needed to improve the supply of inputs (encouraging the private sector, cooperatives to invest more, increasing the number of dealers at strategic locations). Alfalfa is an important poultry-feed component; however, increased production, price reduction, and certification of alfalfa quality are needed. The use of debeaking was found to improve poultry production and create jobs. The service can be given to all smallholder poultry producers regardless of geographical location and production system. The high cost of the machine (ETB6,000) is a consideration. The technology is not appropriate for scavenging chickens. Although the mini-incubators present numerous advantages, a regular supply of electricity is essential.

Implications for scaling out

Fish meal used in poultry feed reduces cost and improves production; it has the potential to replace soyabean around the major lakes where the raw material is available, but appropriate processing and discarding of waste are essential. Fish meal production requires training and coaching for use in other places. The use of commercial formulated ration

is important, particularly around urban/peri-urban areas where the supply of the feeds is available. Alfalfa can be used everywhere regardless of production systems and geographic location; all that is required is a plot of land. Alfalfa does not have negative effects on the environment but rather it improves soil fertility and reduces soil erosion. Debeaking is a feasible technology (individual or group businesses are established/strengthened) for indoor chickens. Access to credit services (banks/microfinance) is important.

Reference

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LIVES small and large ruminant value chain development: approaches and scalable interventions

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ILRI

Introduction

The LIVES project conducted a diagnosis of the production system and agro-ecological characteristics of the project locations in Oromia, Amhara, SNNP and Tigray Regions in 10 zones and 31 districts at the beginning of the project. It was found that livestock production in the project locations was largely traditional. In traditional livestock breeding/mating, the best rams are sold rather than kept for breeding; this practice produces unintended negative selection. In addition, inbreeding risks exist in the absence of planned breeding. In the LIVES regions, there was a shortage of service rams in some areas, such as Sidama Zone. The traditional animal fattening practice included unbalanced fattening ration, small-scale production/fattening and fattening as mainly a by-product of reproduction (culled rams/bucks, draught oxen).

Delivery of improved genetics was unstructured. Genetic improvement of the indigenous small and large ruminant breeds was absent. The focus has been on exotic genetics (crossbreeding) with an inefficient delivery system which resulted in negligible impact after decades of efforts. Conservation-based breeding programs are nonexistent for most breeds. Availability/utilization of locally available feed resources, fodder production and delivery of external feeds was constrained by several factors. Improvement and efficient utilization of grazing lands under 'stock exclusion' are not given due consideration. Veterinary service was constrained by many factors including an overextended public health service, smallholders' low access to private vet services and a veterinary focus that is mainly on exotic dairy cows.

Smallholder livestock keepers' marketing practices mainly target holiday markets, which leads to high supply and low prices. There is also manipulation of the market by middle persons. Livestock keepers also lack market information, operate at small scale, and suffer from irregular supply and nonuniform animals which make access to profitable markets difficult. The LIVES project thus formulated interventions to alleviate these challenges in the project locations.

Context

The LIVES project interventions utilize a value chain approach. The project operates through five pillars: capacity development, knowledge management, value chain development, research/documentation and promotion. The capacity development pillar includes training of partners at the graduate (Master of Science) level, provision of formal and informal training, and regular coaching and mentoring on technology, methods and approaches to market-oriented commodity development by project and partner institutions for value chain actors and stakeholders. Capturing, storing and sharing knowledge through various interventions 'fuels' the value chain development process and complements the capacity development interventions. The project promotes innovative technological, organizational and institutional interventions to improve input supply and service delivery, and boost the production, supply, processing and marketing of market-oriented commodities. Project lessons and results are documented through strategic diagnostic, action and impact studies by project staff in partnership with regional, national and international research institutes. Lessons provide guidance to scaling out and scaling up of results. To reach value chain actors and service providers outside the project target areas, promotional activities are undertaken to scale out and scale up results nationally and internationally.

Description of intervention 1—Delivery of improved small ruminant genetics to smallholders—cooperative village-based small ruminant selective breeding: approach/technology

Livestock breeding programs are broadly divided into centralized nucleus breeding programs and village- (community-) based programs. Genetic improvement in small ruminants based on outside sources of improved rams/bucks has never been a success in Ethiopia. As a result, a new approach was implemented based on a village-based scheme where small ruminant keepers in a community cooperate to implement selective breeding within their own flock. The cooperative village-based scheme also facilitates introduction of other interventions which would be difficult for individual farmers to adopt, such as introduction of strategic health interventions and cooperative access to inputs/ services and marketing of their products at profitable markets. LIVES thus initiated a village-based cooperative small ruminant breeding program in Amhara, Tigray, SNNP and Oromia States.

The intervention integrated genetic improvement through cooperative breeding groups, selected strategic health interventions such as deworming and regular vaccination, feeding interventions (fodder development and value adding on culled rams/bucks and unselected lambs/kids), and cooperative access to inputs and marketing.

Cooperative sheep and goat breeding groups were organized in Oromia, Amhara, Tigray and SNNP States in five districts and nine villages. Sheep and goat keepers within a village were organized as legal sheep/goat improvement cooperatives. The cooperative nominated a ram/buck selection committee to choose the best rams/bucks from the village flocks every mating season. Field days and study tours were organized for value chain actors.

Results

Eight cooperative sheep and goat breeding villages were established in the four regions. The village breeding groups were certified as formal cooperatives. Selective breeding is under way to improve the genetic merits of the flocks. The cooperatives are showing progress and progress was rewarded. For instance, in Bensa Cooperative in SNNP state, two members were recognized and received awards for best ram management (better feeding, housing and health management) and best breeding record number of matings. The occasion served to engage the district officials who planned to work towards establishing market linkage for the cooperative in the district and beyond. Genetic improvement through selective breeding and data collection to estimate genetic progress are under way. Results from similar interventions elsewhere (Gizaw et al. 2014) indicate that cooperative breeding is an effective intervention to improve the genetic merits of the indigenous small ruminant genetic resources.

The eight cooperative breeding villages serve as model villages for integrated small ruminant breeding and production with integrated intervention of genetics, health and feeding. In Amhara (South Wollo), regular and strategic internal parasite prevention/control and vaccination is well adopted in cooperative villages. As a result, mortality was reduced by 85%, for instance in Lomi amba and Genfoch villages in Amhara. Sixty per cent of the households in Gelsha and Tita PAs of Dessie Zuria districts in Amhara facilitated vet services and planted fodder (vetch, oats and tree Lucerne).

Description of intervention 2—Delivery of improved small ruminant genetics to smallholders—hormonal oestrus synchronization for planned lamb/kid production: approach/technology

Lambing and kidding in village flocks is thinly distributed across the year and usually not planned. This has a number of implications. Flock performance is negatively affected if lambing/kidding does not match with appropriate seasons in terms of feed availability and disease load. Dispersed lambing/kidding also undermines the economies of scale of smallholders further (in addition to the already small flock size) for efficient input use and marketing (e.g. bulk

marketing, targeting lambing to match high market demand). Lastly, village genetic improvement (especially selective breeding) is commonly not effective since only a few selection candidates are available in each round of selection due to dispersed lambing/kidding resulting in low-selection intensity and thus slow genetic progress. Hormone-synchronized breeding is a potential solution for achieving planned and concentrated lambing/kidding. Research and development on hormonal oestrus synchronization in dairy cattle has been conducted in Ethiopia for years. The LIVES project extended the technology to small ruminant reproduction and breeding.

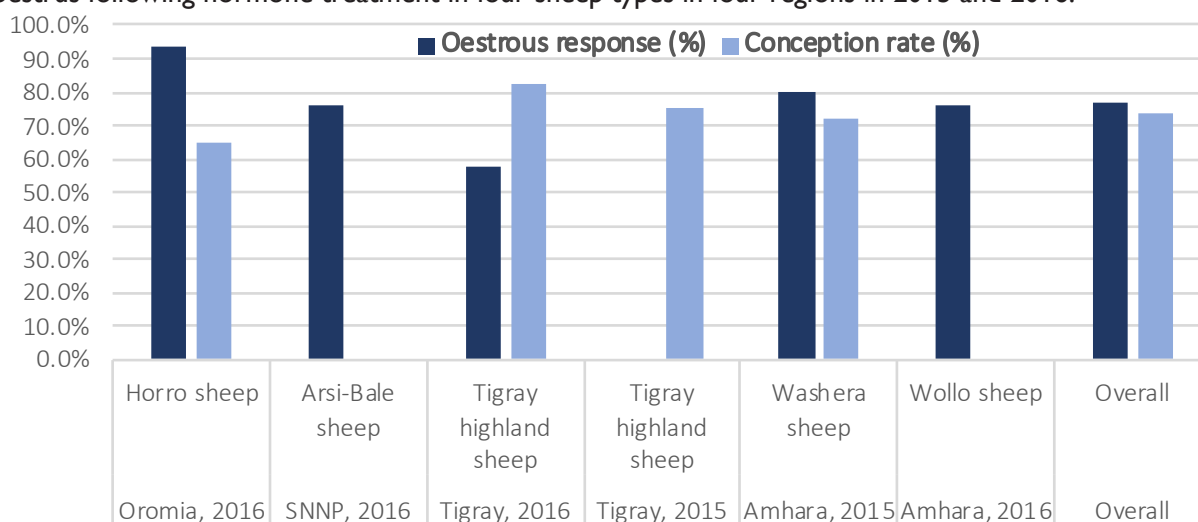
Hormonal oestrus synchronization involves pregnancy diagnosis of ewes/does, identifying nonpregnant ewes/does, and administration of Lutylase hormone at a single dose of 2.5 millilitre (ml) or Estrumate® hormone at a dose of 1 ml per ewe/doe. The majority of the ewes/does are expected to show oestrus within 24–72 hours after hormone treatment and can be bred in seasons favourable for lamb/kid survival and growth. LIVES introduced a pregnancy diagnosis technology called Preg-Tone since ewes/does need to be nongravid for oestrus synchronization.

The technology was first evaluated at Debre Birhan Sheep Multiplication Ranch under controlled conditions. Following promising results from the controlled experiment, the intervention was introduced in cooperative sheep/goat breeding villages. The steps taken included identification of favourable season(s) for maximum lamb/kid survival and growth in consultation with farmers, awareness creation and study tours for farmers and experts, capacity development and linkage with the sources of hormones.

Results

Six action research and development intervention activities were conducted in Amhara, Tigray, Oromia and SNNP States. Oestrus response ranged from 93.2% in Oromia to 57.5% in Tigray, and conception rates ranged from 82.6% in Tigray to 64.6% in Oromia (Figure 1).

Figure 1: Oestrus response to hormone treatment and conception rates as percentage of ewes showing oestrus following hormone treatment in four sheep types in four regions in 2015 and 2016.



Description of Intervention 3—Delivery of improved small ruminant genetics to smallholders—terminal crossing with local sire breeds: approach/technology

Crossbreeding of local sheep with exotic sire breeds has been adopted as a major breeding strategy to improve the productivity of local sheep in Ethiopia. However, there has been negligible project impact on farmers' livelihoods. The major reason for the failure of crossbreeding projects is believed to be lack of appropriate breeding structures

including inefficient dissemination strategies of exotic breeds and development/maintenance of the desired exotic blood level at the village level (Gizaw et al. 2011).

Terminal crossing is a potentially suitable crossbreeding strategy. The strategy is feasible if the sheep industry is structured into ram and meat sheep producers. A terminal crossing scheme does not involve complicated upgrading and is best suited to production systems where flock sizes are small and in areas where establishing a crossbred population is difficult for various reasons. It is suited to tethering systems with fattening practice. Thus, LIVES designed and initiated piloting of terminal crossbreeding using local sire breeds in SNNP and Tigray Regions.

A terminal crossing scheme involves crossing, fattening and selling off all of the crossbred progeny. No crossbred flock is maintained on-farm. The terminal sire breeds are local with a reputation for meat production (Begayit in Tigray and Bonga in SNNP). A group of 20–30 farmers were organized as a breeding group. The group used a ram communally in rotation through handmating. Hormonal oestrus synchronization was also introduced to enable rotation of rams across groups for efficient use of terminal rams and fattening and marketing in batches. An integrated value chain approach was followed including genetic improvement, value addition through fattening, fattening ratio nitrogen formulation, organizing marketing intervention as groups, linkages with profitable market outlets and concentrate suppliers, and other inputs.

Results

Terminal crossing villages were established in SNNP and Tigray. The SNNP intervention was documented as best practice by the Bensa district BoLF in SNNP for dissemination to other areas through South TV. In Tigray, 800 crossbred lambs were born and members of the crossbreeding group benefited from the intervention. Two PAs outside of the LIVES intervention area have also benefited from using the rams to breed their local ewes. In SNNP, twinning rate increased from about 17% to 47.8%.

Description of Intervention 4—Small and large ruminant fattening interventions: approach/technology

The traditional livestock fattening practice of smallholder farmers commonly involves fattening of a culled buck or ram and rarely a single or couple of yearling males, usually once per year, for a long fattening duration extending up to two years, using unbalanced fattening rations or grazing on communal land with salt supplementation. The traditional fattening system does not seem economical (Gizaw et al. 2014). Planned production using appropriate inputs and targeting niche markets is uncommon among smallholders. Therefore, the LIVES project introduced multicycle short-duration fattening techniques in sheep and goats.

Multicycle fattening is a practice of fattening animals many times in a year. The duration of one fattening cycle does not exceed three months in small ruminants and four to five months in cattle.

Bull calves/young animal fattening is a recent practice; young bulls are fattened specifically for beef production. The practice of young cattle fattening can occur in areas where feed is available and demand for young fattened animals is high. Since the cost of fattening young animals is high, good market access is essential. The intervention in small ruminants also includes fattening/finishing of young animals (yearlings) rather than culled old rams/bucks.

Fattening based on locally formulated ration consists of nutritionally balanced home-formulated cattle rations based on feed resources in Demileotora PA of Bonke district in Gamogofa Zone, SNNP State. The major feeds used for ration formulation included maize and sorghum as energy sources, haricot bean as a protein source and salt as a mineral supplement. The contribution of these ingredients to total concentrate mix was 58% for maize, 21% for sorghum, 20% for common beans (roasted) and 1% for salt. The ration preparation was assumed to meet the energy and protein requirements of a cattle weighing 200 kg with expected body weight gain of 1 kg per head per day. The home-

formulated ration was fed at the rate of 1% and 1.5% of a 200 kg cattle. These rations were compared to farmers' traditional practice of cattle fattening.

The LIVES project collaborated with the Amhara Regional Livestock Agency and Mecha district Office of Agriculture to organize a half day 'fattened cattle competition' event in Merawi on 7 April 2015. Sixty smallholder fatteners from Mecha district presented 123 fattened cattle for the competition. The fattened cattle were evaluated by three groups of judges (experts group, farmers group and traders group). Evaluation criteria were body condition and age of the animal. Results from the three groups were displayed for participants and then combined and re-evaluated to choose the final rank for each animal. Animals ranked 1–5 were selected as winners and the owners were presented with prizes.

The approach included capacity development including ration formulation from locally available feed resources and formation of marketing groups and linkages to input suppliers and markets. The project and its partners established marketing groups, identified potential market outlets and channels, worked on improving access to market information at different levels and tried to establish market linkages between producers and traders/consumers (e.g. butchers, institutional buyers) for domestic markets. For instance, 12 marketing groups were established and linked with consumers across districts in SNNP and in Addis Ababa.

Results

In Ejere district, Oromia, the number of households adopting multiple cycle fattening of small ruminants increased. There are now 52 (43 male-headed and 9 female-headed) households practicing multiple cycle fattening. The number of fattened sheep on average reached 6.7 per year/farmer. The number of cycles per year increased from 1–2 to 3–4 cycles/year. The duration of fattening was reduced from five to six months to three months. Annual profit from the business reached on average ETB9,885 for each farmer.

In Oromia, among 105 cattle fattening intervention households (48 male headed and 57 female headed) in Lume district, the benefit of short-cycle fattening is demonstrated using results from a female farmer fattening cows and a male farmer fattening oxen. Results are presented in Table 1.

Table 1: Short-multiple cycle cattle-fattening benefits in Lume district, Oromia

| Farmer | Intervention | Average no. of | | Costs (ETB) | | | | Sale price (ETB) | | |
|--------|--------------|------------------|-----------------|-----------------|------------|----------------|----------------|------------------|--------|--------|
| | | Animal/ cycle | Cycles/ year | Animal/ year | Per animal | Input/ year | Total/ year | Per head | Total | Profit |
| Female | Before | 1 | 1 | 1 | 3,000 | 3,800 | 6,800 | 8,500 | 8,500 | 1,700 |
| | After | 3 | 3 | 9 | 3,500 | 23,782 | 55,282 | 9,000 | 81,000 | 25,717 |
| Male | Before | 2 | 1 | 2 | 8,000 | 7,800 | 23,800 | 13,500 | 27,000 | 3,200 |
| | After | 3 | 2 | 6 | 9,333 | 15,852 | 71,850 | 14,834 | 89,004 | 17,154 |

In SNNP, the economic benefit of short-multiple cycle-cattle fattening for one of the intervention households in the Arbaminch zurio district of Gamogofa Zone is presented in Table 2.

Table 2: Cost-benefit analysis of improved and short-cycle cattle fattening in intervention district of Gamogofa Zone (one farmer in 2015)

| Variables | Cycle of fattening per year | | | Total |
|-------------------------------|-----------------------------|---------|---------|---------|
| | Cycle 1 | Cycle 2 | Cycle 2 | |
| No. of animals fattened | 5 | 6 | 6 | 17 |
| Animal purchasing price (ETB) | 22,300 | 36,750 | 28,700 | 87,750 |
| Feed cost (ETB) | 2,500 | 3,000 | 2,500 | 8,000 |
| Medicine cost (ETB) | 100 | 200 | 200 | 500 |
| Total expense (ETB) | 24,900 | 39,950 | 31,400 | 96,250 |
| Gross income (ETB) | 48,250 | 70,000 | 58,000 | 176,250 |
| Net income (ETB) | 23,350 | 30,050 | 26,600 | 80,000 |

Many of the farmers in Mecha and some in Yilmana Densa districts of West Gojjam Zone, Amhara Region, have adopted the practice of young animal fattening. Market linkage for accessing inputs (feed and medicine) and for selling the fattened cattle have been created through platform meetings, study tours and cattle fairs. For instance, two farmers from West Gojjam Zone, Mecha district, fatten 10–15 young bulls three times in a year. They earn a net profit of ETB3,000–4,000 per bull. This practice is now well-established in Mecha and Yilmana Densa districts and recommended to be scaled out to other districts and zones in the region and beyond.

Daily body weight gain of cattle fed on home-formulated ration at 1.5% of body weight (T3), home-formulated ration at 1% of body weight (T2) and the traditional farmers ration (T1) were 1,147 grams (g), 696 g and 199 g. The average net return (NE) due to supplementation with formulated concentrate at different levels using partial budget analysis was the highest for T3 (ETB4,853) followed by T2 (ETB3,571) while it was only ETB1,825 for farmers ration (T1). However, the marginal rate of return (the return for each birr invested) was highest for T2 (687.8) followed by T3 (532.2).

The cattle fair event was broadcast via Amhara television and radio. The cattle fair led to enormous positive changes in the quality of fattened animals, market access for fattened cattle and income of farmers. The importance of the cattle fair was recognized by the regional livestock agency and local administration. As a result, cattle fairs were organized at Mecha district for two consecutive years (2015 and 2016) and at Yilmana Densa once (2015). The fair has been attended by the Bureau of Agriculture head, Livestock Agency, Bureau of Trade, experts from the region, zone and districts, traders (butcher) and farmers.

As a result of the first cattle fair at Mecha, many of the farmers significantly improved their fattening practice and presented prize-winning animals for the second fair. The number of traders who attended the fair also significantly increased in the second and third round of fairs. Many higher officials and media participated in the second and third events. Over the past two years, the number of fattened cattle produced and sold in Mecha and Yilmana Densa districts significantly increased. Most of the animals are sold to traders coming from Addis Ababa. The unit price per fattened cattle was significantly improved as a result of the cattle fair promotion. For example, a bull was sold for ETB60,000 in 2016 which might be the highest price ever recorded in Amhara Region and probably in the country.

Description of Intervention 5—Linkages to commercial feed sources and markets: approach/technology

Linkages are important as drivers of value chain development. In Tigray, LIVES facilitated linkages between sheep fatteners in villages and district towns and concentrate suppliers in the regional capital, Mekelle.

Results

Farmers were able to access concentrate feeds (about 91 quintal purchased), adopt multiple-cycle fattening and improve farm income (Table 3).

Table 3: Farmers engaged in multiple-cycle sheep fattening and income generated from the business

| Farmer | Income generated (ETB) | No. of cycles | District | PA |
|----------|------------------------|---------------|----------------|--------|
| Farmer 1 | 19,000 | 3 | Atsbi Wemberta | Habes |
| Farmer 2 | 80,000 | 3 | Kilte Awlalo | Negash |
| Farmer 3 | 37,000 | 3 | Kilte Awlalo | Negash |
| Farmer 4 | 77,000 | 3 | Kilte Awlalo | Negash |

Key lessons and challenges

A value chain approach (access to inputs/services and profitable markets) is a key to adoption of production interventions by smallholders. Capacity development (skill training, coaching and mentoring, and graduate student training) is a key component of commodity value chain development.

Implications for scaling out

Documenting evidence through action research is a prerequisite for packaging interventions for scaling out. Regarding hormonal oestrus synchronization for planned lamb/kid production,

in Amhara Region, 414 ewes were synchronized and about 240 smallholder farmers benefited from the technology (Gizaw et al. 2016; Tegegne et al. 2016). The feedback from beneficiaries was positive and requests came from the regional livestock agency and zonal and district administrators of West Gojjam, South Wollo and North Gondar Zones to scale out the technology. In Tigray, a field day on sheep synchronization was celebrated in Saesie Tsaeda Emba district Hadnet PA and lessons learned from sheep synchronization were shared with extension staff in Saesie Tsaeda Emba with about 90 participants including extension staff, district/zonal administration, private concentrate suppliers and sheep keepers. The Tigray Agricultural Research Institute adopted the intervention to scale it out to nonintervention districts in collaboration with a development partner, Operational Research.

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Mainstreaming and promoting gender equity in market-oriented agricultural development: experiences from the LIVES project in Ethiopia

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Introduction

Studies indicate that agricultural value chain development and market-oriented agriculture need to be designed and implemented in a gender-sensitive manner so that opportunities and gains benefit women as well as men (Aregu et al. 2010; Lemma and Tesema 2016; KIT et al. 2012; Njuki et al. 2012; Gebremedhin et al. 2016).

Accordingly, the LIVES project approached the gender mainstreaming task using pragmatic and innovative approaches to ensure equal benefits to male and female smallholders in both livestock and irrigation value chain development and governance.

Gender analysis

As Ethiopia implements the second nationwide Growth and Transformation Plan (GTP II 2016), most of the lessons and experiences of gender-related innovations and approaches from the LIVES project receive momentum to be scaled up and out in the upcoming years. GTP II envisages increased participation of women in agriculture from 27% to 50% by engaging 10.1 million women in agricultural and 1.5 million women in nonagricultural activities (GTP II) by 2020.

This paper presents the experiences collated over the last four project intervention years. The well-argued gender transformative research for development (Njuki et al. 2012) and chain empowerment approaches (KIT et al. 2012) were tuned to fit into livestock and irrigation value chain development in mixed-crop livestock systems in Ethiopia. Thus, LIVES used well-grounded conceptual, strategic and pragmatic approaches to ensure gender inclusiveness and empowerment in its value chain intervention.

Context

The socio-economic context of the LIVES intervention dominantly reflects a smallholder-based subsistence agriculture mainly situated in the highland mixed-crop livestock systems where market orientation is not full-fledged and just beginning to benefit male and female smallholders engaged in both livestock and irrigation activities.

In terms of gender norms, women struggle with traditional practices which undermine their role as farmers and market actors, including limited decision-making at household and community levels. For ages, as the major thespians of the domestic sphere, women suffer from 'time poverty' as a result of which their involvement in education, productive activities and physical mobility for marketing livestock and irrigated crops remain limited mainly to the farm gate and village market in most cases. As LIVES baseline survey results reconfirmed, there are huge gender differentials in terms of ownership of productive assets, water use-related technologies and intermediate means of transportation which contribute to disproportionate disadvantages for women in both married households as well as in female-headed households (Tesema et al. 2016).

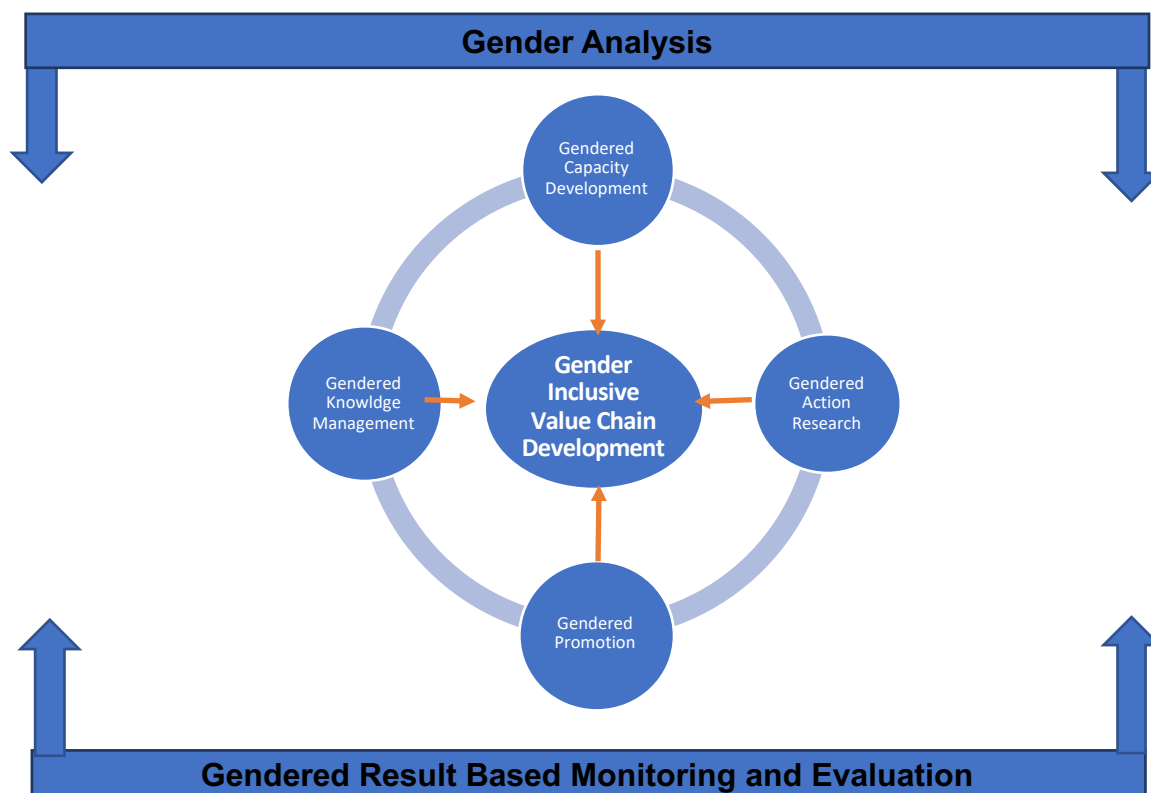
Description of the intervention: approach/technology

The LIVES gender-equitable livestock and irrigation value chain development intervention aimed to increase production, productivity and household income of male and female smallholders in four regions of Ethiopia. As a result of its four-year gender-balanced intervention, LIVES filtered five innovative gender approaches as scalable by key project partners in the near future. These five scalable gender innovative approaches envisioned the enhancement of smallholder women's participation in livestock and irrigation value chains mainly through individual women's economic empowerment, enhanced couples-managed (husband/wife) household-based enterprise development, encouraging innovation and technology use by model women smallholders and through increased visibility of women's contribution in agricultural value chains by involving them in promotional events and in events that can lead to enhanced confidence and morale.

In addition, LIVES has made concerted efforts to ensure the creation of a gender critical mass within the public extension system through capacity development, gender sensitization and involvement of extension services in intensive gender data collection, analysis and reporting using standardized gender analytical tools on livestock and irrigation value chains. In short, the following gender approaches and innovations are filtered as lessons and good practices that deserve replication (scale out and up) by key partners engaged in research for development intervention in the agricultural sector.

In order to bring about gender-equitable outcomes, the project followed a value chain intervention approach through which gender analysis results were integrated across project pillars (capacity development, value chain development, knowledge management, action research and promotion).

Figure 1: Engendering project pillars to promote gender-inclusive value chain development and governance.



Stakeholder involvement has been part and parcel of project design, implementation planning, familiarization and monitoring. All value chain actors (input suppliers, public extension, farmers, research system etc.) are key stakeholders involved as active partners throughout the project intervention. In order to enhance gender mainstreaming in the value chain, the lower echelon of the Ministry of Women, Children and Youth, gender unit leaders, focal persons and women associations were involved in platforms, mobilized women value chain actors and gave input during monitoring of gender achievements.

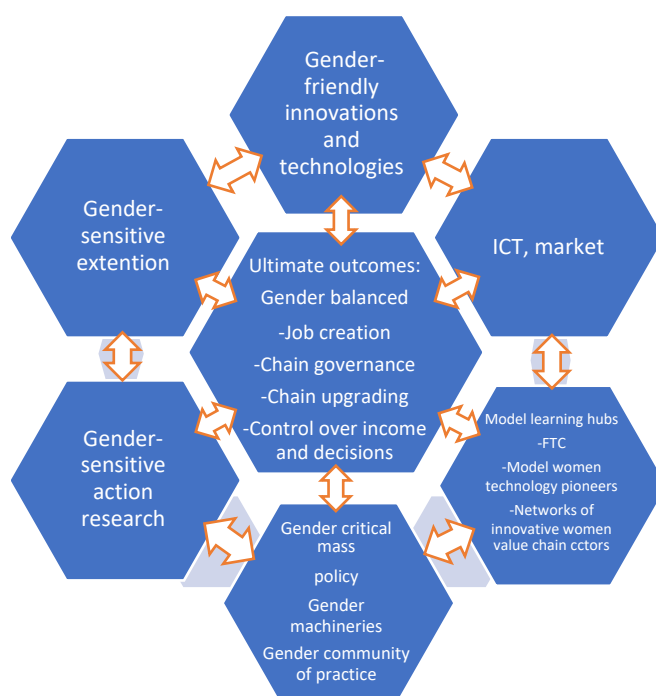
Results

The following are gendered-project outcomes to be scaled out and up by key project partners in the agricultural sector. They were filtered out as outstanding examples at this stage of the project intervention.

- 1) Women Privet Input Supply (grafted fruit seedling, pullet, concentrate livestock feed, feed seed etc.)
- 2) Couples (husband/wife) Enterprise Development (improved and integrated poultry, dairy, apiary (wax and honey))
- 3) Model Women/Gender-Friendly Technology Users as Facilitators of Technology Adoption
- 4) Women Promotional Events (school/World Milk Days, Farmers Horticulture Day, exhibitions, certificates/awards, field days)
- 5) Creating Gender Critical Mass in the Public Extension Sphere (task-based networking)

LIVES project interventions impacted a number of gender-sensitive livestock and irrigation value chains and nodes as the result of which new household enterprises have been created, village-based and women-led rural services emerged, participation of women in community-based structures (IWUA) and in community-based small ruminant breeding committees increased, and new jobs and specializations (women seed feed suppliers, concentrated feed suppliers, pullet producers and suppliers, couples-based enterprises and women privet input supply) emerged.

Figure 2: LIVES experiential and social learning for gender mainstreaming: Enablers for inclusive value chain development and the central outcomes.



Key lessons and challenges

The design of an appropriate gender strategy to guide the intervention and stipulating a gender target in the results-based monitoring and evaluation framework are primary tasks of a gender-sensitive value chain intervention. In addition, internal and external capacity development, facilitating institutional innovation in key public sector partners and creating gender critical mass by involving all gender-related sectors and stakeholders ensures sustainability and transforms gender empowerment in agriculture.

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Results-based monitoring and evaluation for agricultural research for development (AR4D) projects: synthesis of experiences from two ILRI AR4D projects in Ethiopia

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ILRI

Introduction

Monitoring and evaluation (M&E) is an essential management tool that contributes to informed decisions based on objective evidence. Moreover, it ensures the most effective and efficient use of resources, and objectively assesses the extent to which results are achieved. It also aids in learning from experience and meets organizational and donor reporting requirements.

The traditional implementation-focused M&E approach has been the dominant practice in most development and research projects and programs. Implementation-focused M&E systems are designed to address issues of compliance with plans, such as answering questions like ‘did they do it?’ (Kusek and Rist 2004). This approach is concerned with output achievement using available inputs and activities. Hence, the data collected are largely operational such as tracking of funds and other inputs and processes, and the outputs achieved. This M&E system fails to provide decision-makers and stakeholders with an understanding of the success or failure of the project/program/policy with regard to meeting intermediate and long-term results.

AR4D projects have their own unique features. AR4D interventions are demand driven and address pressing needs of target beneficiaries. These projects have developmental relevance expected to bring developmental change for the targeted beneficiaries. Furthermore, AR4D projects are participatory and involve partners and stakeholders in the planning, implementation and M&E. Another key feature of AR4D projects is their problem focus as opposed to a methods-driven approach found in conventional research activities. AR4D projects are multi/interdisciplinary attempts to solve developmental problems. In general, AR4D projects are designed to bring higher-level developmental results with active involvement of beneficiaries and stakeholders. Hence, these projects require an M&E system that can capture results and lessons in a participatory and flexible manner.

Results-based monitoring and evaluation (RBM&E) is an appropriate approach to monitor and evaluate AR4D projects. RBM&E aims to expand the implementation M&E function to include results (outcomes) explicitly. It is designed to answer the ‘so what?’ questions. Hence, RBM&E provides feedback on different levels of intervention outcomes. RBM&E uses more qualitative and quantitative information on the progress towards outcomes. Moreover, it involves partners and stakeholders in the process and gives attention to perceptions of change among stakeholders, as well as capturing information on success or failure and lessons in achieving desired outcomes (Kusek and Rist 2004).

Hence, ILRI used RBM&E for two AR4D projects for about a decade and half. This paper discusses the process, results, lessons and challenges of the ILRI experience in designing and implementing RBM&E to monitor and evaluate AR4D projects.

Context

ILRI implemented two interrelated AR4D projects in Ethiopia. The first was the IPMS project, funded by the Canadian International Development Agency. The project was implemented with the MoA from 2004–12 with the aim of transforming the smallholder subsistence farming system to a more commercial-oriented agricultural system. In this project period, much emphasis was given to test/develop new approaches and interventions with project partners in four regions and 10 pilot learning woredas/districts. The second project, LIVES, is aimed at improving the economic wellbeing of male and female smallholder producers through the development of livestock and irrigation value chains. The project works with public and private sector partners in 31 districts in 10 zones of the four regions (Amhara, Oromia, SNNP and Tigray) in Ethiopia. The project is implemented jointly by ILRI, IWMI, MoA, Ethiopian Institute of Agricultural Research (EIAR), and regional agricultural bureaus. The project has a six-year duration from 2012 to 2018. LIVES is primarily concerned with the scale out of successful approaches and interventions achieved under IPMS while focusing on a limited number of key high-value livestock and irrigated crop commodities. In summary, both projects have similar approaches and modalities even though they have different scales as the first is more of a pilot project while the latter is a scale out and up project to expand/promote the good practices from the previous phase.

Description of the intervention: approach/technology

The RBM&E implementation process can be broadly classified into four phases: design/redesign the system, develop capacities, implement the system and use the M&E information. The following sections discuss each stage briefly.

Design/redesign the RBM&E system

Design/redesign/review logic model (LM) and Performance Measurement Framework (PMF): As a strategy for measuring project performances/results, IPMS/LIVES developed and used an RBM&E system. The system is based on the project's logic model LM and PMF. The former describes the theories of change/logical relationships among the different hierarchy of results the project aims to achieve across the project period. The latter consists of the indicators to measure the expected project results, baselines, targets, sources of data, data collection method, frequency of data collection and responsible body. The design of the RBM&E system for the IPMS project was carried out with the help of an external consultant while for LIVES, in-house capacity was used to redesign the system.

Developing M&E data collection systems: The project designed a combination of data collection methods in line with the different hierarchy of project results and type of indicator, and the size and complexity of the data to be collected. The data collection methods employed by the projects for each hierarchy of result are described below.

Ultimate outcomes: Household surveys were designed for projects. Paper assisted personal interviews (PAPI) were used for IPMS while a Computer Assisted Personal Interview was used for LIVES. For LIVES, the baseline survey was not only intended to set baseline values for the ultimate outcome indicators but was also used to generate data that were used for research purposes. Moreover, rigorous impact evaluation methods were designed for assessing the impact of the project.

Intermediate outcomes: For the LIVES project, a community survey method was used for data collection for this result level. Consequently, baseline and midterm community surveys were conducted to assess the changes on the intermediate outcome indicators using PAPI. This method was selected due to the nature of the indicators, type and frequency of data collection required and cost implications.

Immediate outcome and outputs: For this level of results, data need to be collected most frequently. Therefore, the LIVES project designed web-based data collection formats that were uploaded on Google drive so that it could be updated continuously online by project staff from the zones and regions. For IPMS, these data were collected using paper-based formats.

Addressing cross cutting issues in the M&E system: Conventional M&E systems that are gender and environment blind do not capture gender differences and the environmental issues. The projects designed an M&E system that is gender- and environment-sensitive in all aspects. The project's PMF has gender-sensitive result statements and performance indicators. Moreover, the baselines and targets are disaggregated by gender; the data collection methods and tools are designed in such a way that data are collected in a gender-disaggregated manner. Likewise, the results statements are designed with environmental considerations. Environmental sustainability is included in the statements so as to ensure that it is considered in project implementation, monitoring and evaluation. Moreover, the projects have an environmental framework with indicators for possible environmental effects. The projects have continuously monitored the possible negative environmental effects of project interventions and application of the mitigation measures.

Developing capacities

One of the key important aspects of RBM&E implementation is building the capacity of actors involved in implementing the system. Successful implementation is highly dependent on project and partners staff knowledge, skills and abilities to develop and use the RBM&E system. Therefore, the project developed an RBM&E guide and organized training for project staff, partner staff and other stakeholders on the principles and practices of RBM&E.

Developing RBM&E guideline: An RBM&E guideline was produced based on review of available theories and practices. The guideline details how RBM&E should be designed, implemented and institutionalized. Hence, after discussion of relevant theories and concepts, the guide describes how to construct results statements and key performance indicators, set baseline and targets, design performance data collection systems, collect and analyse performance data, report and use performance information and sustain RBM&E systems. The guide can be accessed at http://www.focusintl.com/RBM070-9291462454_content.pdf.

Organize training on RBM&E: The project organized training on RBM&E for project staff, partner staff from the four regions, zones and districts and universities. Most of the training activities were carried out during the IPMS project to create awareness and develop skills for the new RBM&E approach. A total of 230 people were trained in all aspects of designing, implementing and using the RBM&E system based on the RBM&E guideline. The training was organized by region; one training occurred at the national level. Each training event consisted of five days of theoretical and practical sessions.

Coaching and mentoring partner staff on RBM&E: After the training, coaching and mentoring of partners' staff were carried out by project staff throughout the implementation process. There is frequent partner staff turnover and regional and zonal staff provide practical coaching and mentoring support to ensure that all the newly appointed staff understands the concept of RBM&E and are involved in the implementation process. Coaching and mentoring sessions were conducted both during IPMS and LIVES project durations.

Implementing the system

It is important to ensure that the entire RBM&E system is implemented as per the design. Key factors to implementing the system are described below.

Data collection and analysis: Data were collected for each PMF indicators using the data collection methods agreed upon in the design phase. The timing and frequency of data collection varies. The data collected were analysed using appropriate data analysis software. One important issue in data collection and analysis is to ensure that data are disaggregated by gender.

Produce reports: Reports are produced using the information generated from the collected data to satisfy the information needs of management, partners and donors. The reports also address crosscutting issues like gender and environment.

Disseminate findings: The RBM&E findings are disseminated to all concerned bodies using reports, workshops, meetings etc.

Review the system and adjust: The RBM&E system requires continuous review and improvement based on lessons from practical applications. Hence, there have been some changes to the system corresponding to practical experiences across the years.

Using the RBM&E information

The merit of any RBM&E framework is determined by how much the information is utilized by the intended users (Henry and Mark 2003; Patton 2008). However, limited use of RBM&E information has been the major challenge in many projects and programs. One strategy to improve utilization of RBM&E information is linking annual planning with RBM&E. The projects used two strategies to incorporate RBM&E information into the planning processes, described below.

M&E information used for identifying focus areas: Before preparing the annual plan, the planning team reviews all M&E reports (both from internal and external monitoring) to identify areas that need attention in the planning period. Performances, challenges and lessons are reviewed and used as a basis to prepare the draft plan.

Monitoring and feedback from project steering committee and stakeholders: The project performance are reviewed (based on field visits and RBM&E reports) by zonal stakeholders, regional project implementation committee and project steering committee members during annual planning workshops. The members provide direction for future planning after reviewing project accomplishments, challenges, gaps and lessons.

Results

The fact that the projects use RBM&E ensure that results are measured effectively and efficiently. Furthermore, the quality, timeliness and costliness of data collection have greatly improved due to use of combinations of data collection methods and modes. Since the system was designed to be sensitive to both gender and environment, it is possible to capture gender differences in outcomes and ensure the environmental friendliness of interventions. Improved RBM&E information utilization is another key result of the system. For instance, the approach ensured that RBM&E information is effectively utilized in the annual planning. Consequently, components with low performance received increased attention in the annual plans along with corrective measures. Moreover, partners and stakeholders are involved in review of performances and suggest improvements in the Annual Work Plans accordingly.

Key lessons and challenges

There is no blueprint or one-size-fits all RBM&E approach; modifying to demand is crucial. Hence, we have designed our RBM&E approach according to our demand and context. Moreover, piloting the system is very important. During LIVES, a number of improvements were made to the RBM&E system after documenting lessons during its piloting phase in the IPMS project period. RBM&E is about learning from experience what works and what doesn't; there is always incremental learning. Flexibility of the system is fundamental; there is a need to learn, review and adjust the system continuously. Capacity building is key as knowledge and skill are essential ingredients for successful implementation of the system. More importantly, behavioural change both for the managers and staff in terms of results orientation is fundamental which makes establishing a well-functioning RBM&E a long-term process.

For AR4D projects, cost for RBM&E data collection could be decreased by combining it with research. The RBM&E data collected were used for various research purposes. For instance, LIVES household baseline data contributed to more than 15 diagnostic research papers. Another key lesson is it is crucial to use a manageable number of performance indicators as it will not only have quality but also cost implications on RBM&E data collection.

The key challenge in establishing an RBM&E system is cultivating a favourable environment that promotes results orientation. This requires a change in organizational culture from the long-standing implementation and process-oriented to results-oriented. This not only requires time and commitment of higher officials but also obtaining buy-in from staff, partners and other stakeholders involved in the implementation processes.

Implications for scaling out

Scaling out this approach requires adoption of a results-based management system and cultivating results-oriented organizational culture. Moreover, organizational commitment, especially from higher officials, is mandatory. Equally important is the involvement of staff and stakeholders in the design and implementation of the approach. It requires adequate financial and human resources and organizing capacity-building activities, especially during the early years of implementation.

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Africa RISING

The Africa RISING program is comprised of three research-for-development projects supported by USAID as part of the U.S. government's FtF initiative.

Through action research and development partnerships, Africa RISING creates opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three regional projects are led by the International Institute of Tropical Agriculture (IITA) (in west Africa and east and southern Africa) and ILRI (in the Ethiopian Highlands). The International Food Policy Research Institute leads the program's monitoring and evaluation project.

The overall aim is to transform agricultural systems through sustainable intensification projects in three regions of Africa:

- West Africa: Sustainable intensification of cereal-based farming systems – led by IITA
- [Ethiopian Highlands: Sustainable intensification of crop-livestock systems – led by ILRI](#)
- [East and southern Africa: Sustainable intensification of maize-legume-livestock integrated farming systems – led by IITA](#)

These regions were chosen based on analysis of cropping systems, poverty, population, country development priorities and the potential for successfully improving agricultural productivity.

These projects also contribute to CGIAR's integrated 'systems' research programs on drylands and on the humid tropics.

<https://africa-rising.net/about/>

Institutional innovation platforms (IPs) for sustainable intensification in the Ethiopian highlands

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ILRI

Introduction

Sustainable intensification requires a systems research approach to address the different components of smallholder farming particularly in a mixed crop-livestock farming system. Agricultural research for development requires the engagement of various research and development partners through collective actions to address specific problems and achieve development outcomes. The engagement of multiple research and development partners requires institutional innovation that facilitates interactions and creates meaningful collaboration for joint action. IPs are a widely recognized approach to create space for different actors to come together for learning and change. In general, the aim of setting up IPs and facilitating interactions is mainly for combining scientific and local knowledge that results in innovations to bring impact at the local level. Evidence demonstrates that IPs can be established and facilitated to address different agricultural problems in specific local areas.

Context

Local-level IPs in Africa RISING project sites in the Ethiopian Highlands were established and facilitated mainly for learning and change, and to increase the impact of sustainable intensification (SI) interventions to achieve development outcomes. The IPs operate at three levels—woreda (district), kebele and farmers research group (FRG)—to create opportunities for cooperation and co-learning that identify suitable SI interventions and support scaling up. In each project site, IPs have facilitated meaningful and effective interactions that have prioritized, guided, and evaluated the various research and development processes. Regular learning events on planning and reflection as well as annual farmers' field days organized for all IP members and farmers (participating and nonparticipating) helped the project to leave its legacy among the local actors who have already started partnering to scale up the suitable SI interventions at their sites. Phase II strategies and activities on partnership will sustain momentum for wider scaling up while maintaining and transferring knowledge to all actors in new areas.

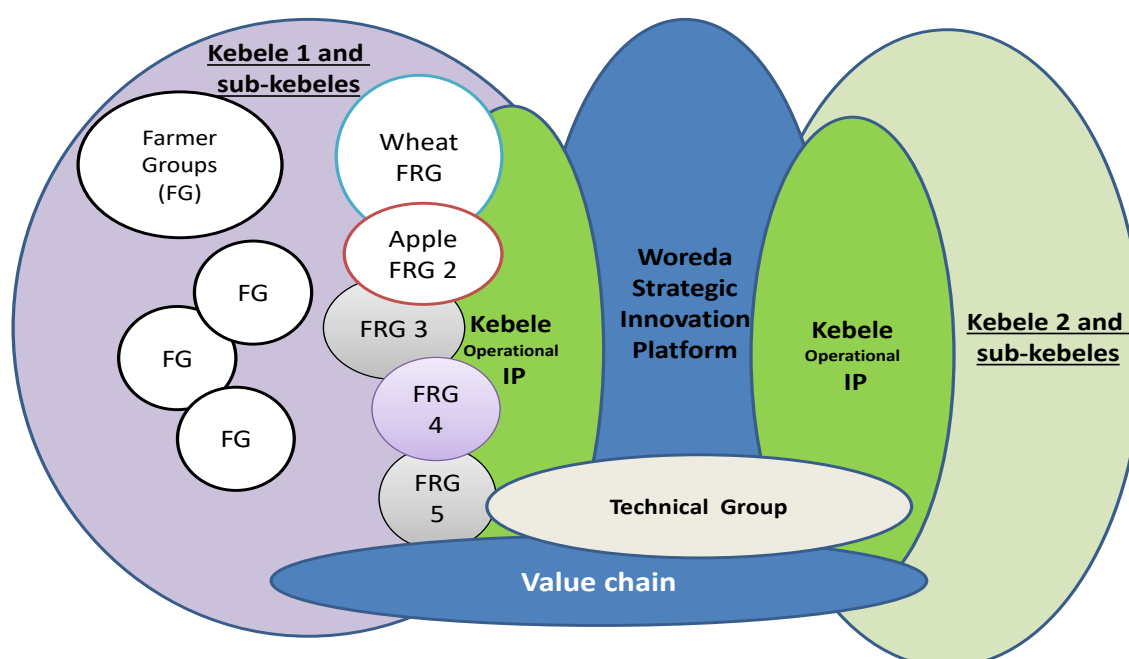
Description of the intervention: approach/technology

The table below shows the three levels where IPs operate. These are all interlinked within the district and established around commodity-based action research. Four strategic IPs, eight operational IPs and many more innovation clusters were established.

Table 1: Name and number of IPs established at three levels in each Africa RISING site

| Woreda strategic IPs | Kebele operational IPs | No. of FRGs |
|----------------------|------------------------|-------------|
| Lemo | Layignaw Gana | 9 |
| | Jewe | 9 |
| Sinana | Ilu-Sanbitu | 7 |
| | Selka | 6 |
| Endamehoni | Tsibet | 8 |
| | Embahasti | 6 |
| Basona Worena | Goshe Bado | 7 |
| | Gudo Beret | 8 |

Figure 1: Africa RISING IP network at woreda level (research sites).

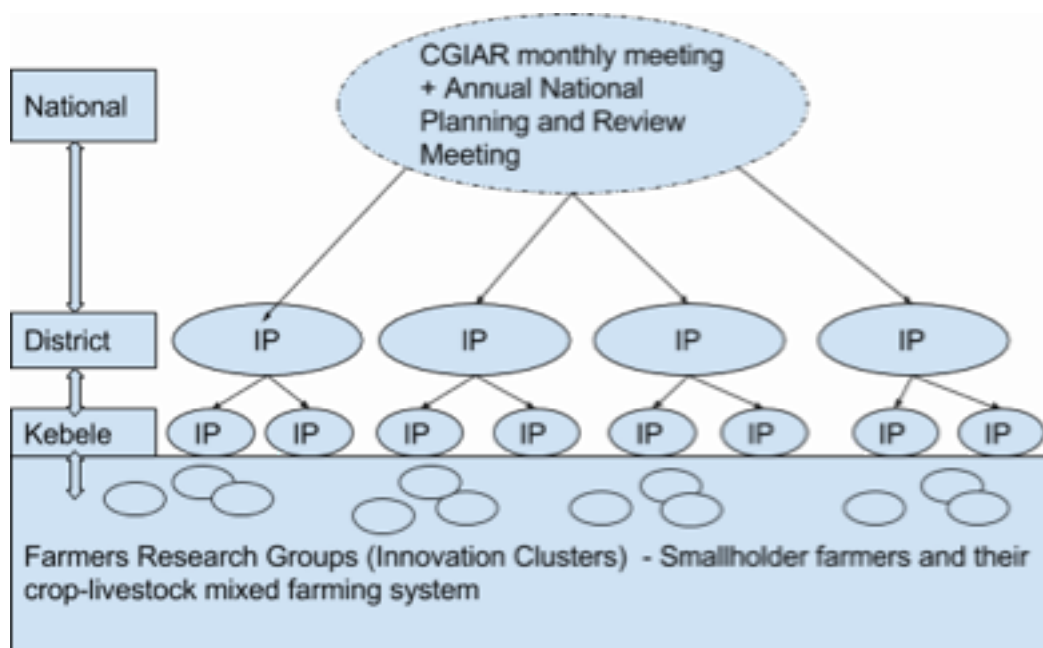


Upon establishing these platforms, the project built upon lessons learnt from experiences with IPs in a previous project of the ILRI, the Nile Basin Development Challenge (NBDC). One of the key lessons from NBDC was that setting up community level platforms helped smallholder farmers increase access to knowledge, participate actively and build trust with other platform members through action research activities leading to ‘quick wins’. Therefore, operational and innovation clusters were linked with strategic IPs in each district in Africa RISING.

At the national level, a monthly meeting among all CGIAR centres participating in Africa RISING was hosted by the project team to learn and share about systems research undertaken in the FRGs. This is a unique project that brought about nine CGIAR centres to work together on systems intervention at the same site for the same goal.

At the district level, the four strategic IPs connected to kebele operational IPs (five operational IP members were selected to be part of the strategic IP) and FRGs through small technical groups set up at kebele level and interacting frequently. These technical groups helped with IP coordination, facilitation, communication and capacity development.

Figure 2: Linkages among Africa RISING knowledge sharing, IPs and innovation clusters.



Membership composition and purpose of IP networks

The Africa RISING IP team identified specific members at each level, based on their contribution, role and interest as a local partner to the Africa RISING project.

Strategic IPs at district level: This IP is 'strategic' as it is established 'at a higher level of governance and management, where strategies are determined for agricultural development' (Ellis-Jones et al. 2014). In this case, strategic IPs were established at district level where local decision-makers, extensionists, NGOs, university, local research centres and participating smallholder farmers in research activities from both Africa RISING research kebeles and other key actors are located to create good synergy for joint action research to deal with SI issues specific to the local context.

Strategic IPs or coalitions might target chief executives or directors of stakeholder organizations to agree upon strategies to promote innovation along value chains or systems. They can also facilitate the operations of IPs at implementation levels. (Ellis-Jones et al. 2014). In the four Africa RISING strategic IPs, 25–30 local members were involved, notwithstanding CGIAR centres who participated in the IP events.

Strategic IP general assembly: The general assembly was scheduled to take place four times per year, but this proved too taxing for the project budget. In practice, it met at least two times per year: one joint planning meeting for research trials and one evaluation meeting with a visit to farmers' sites and/or a 'farmers' field day' where research trials were demonstrated. Having these two annual events across the four districts helped its members engage in a process of learning and knowledge co-creation around innovations, and later to gauge their scaling potential. Much effort was put into engaging local actors to build trust, own the process, and make better-informed decisions and support scaling out efforts within their district.

Strategic IP technical committee: Eight to ten key actors were nominated by the IP to form a 'technical committee' that would provide facilitation, coordination, monitoring and evaluation, gender mainstreaming and technical support to the operational IPs and innovation clusters. This technical committee also organized learning events at all IP levels, such as the annual farmers' field days. In each district, the technical committee members represented agricultural universities, agricultural research centres, district authorities responsible for livestock/crop/natural resource management (NRM) and local NGOs.

Operational IPs at kebele level

In each Africa RISING district and under each strategic IP, two operational IPs were established at the Africa RISING research sites to engage the actors who were at the heart of the research process and scaling out efforts. All operational IP members were from the kebele. They included: community leaders, crop/livestock/NRM development agents, women and youth, farmer cooperatives' representatives and farmers participating in action research through innovation clusters. 'They participate in the activities of the platform because of the relevance of their expertise to address specific questions.' (Ellis Jones 2014).

Operational IP technical committee: As in the strategic IP, operational IP members were nominated to support the facilitation, community mobilization, communication and coordination activities within their kebele as well as to provide technical support to the innovation clusters participating in action research trials. With support from the district technical committee, they also played a key role in organizing farmers' field days by mobilizing participating farmers to demonstrate their action research work in their farm fields as well as neighbouring farmers (to encourage farmer-to-farmer technology dissemination). Similarly, operational IPs planned to organize quarterly meetings, one centred around a farmers' field day.

Innovation clusters at FRG level

As mentioned in the IP guidelines, 'Any partners working on testing of technologies at farmers' level are expected to conduct their activities through Farmers Research Groups.' The project team thus undertook a number of context-specific action research activities involving farmers in more than nine FRGs (or 'innovation clusters') to test and adapt technical, institutional and technological innovations at each site. Across the eight kebeles, research activities bore similarities but also addressed specific local needs.

Learning process across the IP networks

At local level, the learning happened at different levels. Training is designed to engage members of IPs from planning to evaluation annually by creating a space for individuals to interact and discuss most of the research activities before implementing and to critically review from the local specific context and their valuable experiences. The annual learning cycle at district level includes two key events.

The first event focused on planning a general assembly for strategic learning and the second event was a 'sharing' meeting organized around site-specific research activities identified before implementation. This is to engage stakeholders in research that targets an issue of local prioritized agendas. It is also a space where members of the platform coming from research organizations ensure that duplication of efforts does not occur and to encourage building on existing practices and efforts. This event was also facilitated to encourage others to share their experiences and discuss opportunities to learn from and link with other stakeholders for improved and effective intervention. The roles and responsibilities of community and kebele-level members participating in the strategic IP are to mobilize community, identify and convene participating farmers, and mobilize the community for farmers' field days and other activities.

Results

The Africa RISING phase 2 proposal for the Ethiopian Highlands recalls the importance of IPs among partnership mechanisms: 'The IPs have been very active and engaged in phase I and have made direct inputs into focusing and prioritizing the research. The woreda level IPs reviewed all research proposed for their sites, in some cases rejecting research that they did not consider appropriate or high priority. The FRGs formed the basis for engagement of the research teams at household level using an elective model for determining households' participation in specific research protocols. This model has been instrumental in building strong trust in our target communities where, in the past, farmer participation in specific activities may have been dictated by research teams.' (phase 2 proposal, p. 14).

The same proposal also states: 'IPs and FRGs have greatly enhanced communication among CGIAR and local partners, farmers and local policymakers on understanding system, identifying opportunities, conduct of research and review of results and impacts.' (ibid., p. 15)

Key lessons and challenges

Various lessons are worth drawing out of the experience of the first phase of Africa RISING with IPs. The opportunity to not only diagnose better agricultural practices but also to really experiment with and implement agricultural technologies proved the strongest way to rally farmers' votes and participation in the IP. Therefore, compared with the NBDC experience, incentives to join the IPs were not an issue.

Facilitation and mediation were as critical as in previous experiences, and supporting and developing these skills (through the training, release of manuals, ongoing coaching and nomination of facilitation champions) proved a winner for Africa RISING as due diligence was paid to ensure a strong and smooth stakeholder gelling process—and this was not a given as Mohammed Ebrahim can testify: 'Facilitating partners' engagement and bringing different institutions together for common objectives was the most challenging part of the project work. It needs a special communication skill and effort.' Even more efforts need to go into supporting facilitation by local site coordinators, to ensure maximum participation and collective capacity for genuine collaboration and innovation.

A site coordinator on the ground to 'hold it together' and play a key role both in IP meetings and ongoing research activities was one of the most fundamental 'wins' for IPs to function effectively. Coordinators could keep the network together and feed information back to the (Addis-based) rest of the Africa RISING team.

Collaboration and participation were not considered token, but rather fertile ground for IPs and well beyond. Thus, the participatory nature of Africa RISING was not confined to IPs but was also concerned with many other aspects and phases of farmer and stakeholder engagement: rapid telephone surveys, sustainable livelihood asset evaluation, rapid market assessment, participatory community analysis, agro-ecological knowledge toolkit, Integrated Modelling Platform for Mixed Animal Crop systems (IMPACT)lite, and value chain studies (Lema et al. 2015). This strengthened the trust that various IP members put in the process.

Although IPs started off as just another 'research protocol' for Africa RISING in the Ethiopian Highlands amidst other agronomic research protocols, they were supported by the project management team and as such they progressively involved more and more collaborating research institutes, who decided to subscribe to the approach to implement their research protocols.

Implications for scaling out

Encouraging farmer cross-learning through study tours, farmers' field days, participatory varietal selection etc. proved a great way to engage farmers and encourage buy in to Africa RISING work via IPs. This is one of the reasons why Africa RISING's Ethiopian Highlands won an award for their USAID project, '[Collaborating, Learning and Adapting](#)' [case study](#) which focused on IPs, among other topics.

While the NBDC revealed a strong potential for IPs, Africa RISING built upon this success to establish an even stronger set up for collaboration, learning and research that lead to SI and ever improving livelihoods. The case is there and the momentum is up for grabs.

Landscape management: Africa RISING project R4D experiences in the Ethiopian highlands

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Introduction

Land degradation is a serious problem in Ethiopia. With a human population of 100 million and livestock population of 150 million, pressure on resources will likely increase. Climate change, especially rainfall variability, also contributes to pressure on the already constrained environmental and economic resources. Farmers' decisions to invest in necessary agricultural inputs and involvement in soil and water conservation can also be influenced by uncertainties in climate regimes.

Sustainable intensification is a viable option to improve productivity as it is not possible to continue expanding agricultural areas to support a growing population. Experience, however, demonstrates that intensification at plot/farm level can not be achieved efficiently and sustainably while degradation takes place at landscape/watershed levels. Consequently, widespread promotion of sustainable land and water management (SLWM) practices is required to reconcile increasing population density and improved agricultural productivity while enhancing overall ecosystem services. Against this background, a major landscape restoration effort has been under way in Ethiopia since the 1970s. To date, millions of ha of land have been conserved through the construction of terraces, deep trenches, percolation ponds etc. and billions of trees planted across the country. In various strategies (GTP I, GTP II, AGP, SLM, CRGE) the country has devised commendable initiatives to improve productivity while protecting the environment.

Despite that fact that there are no comprehensive studies that evaluate the performances of the various interventions, overall adoption of SWC and SLM interventions continues to be low (Mekonnen and Michael 2014). This can be attributed to limited direct economic benefits from interventions, long gestation period of most interventions at watershed scale before benefits accrue, options not well matched to the biophysical and socio-economic realm, interventions are not complementary and thus have limited synergies, and interventions are not planned and implemented in a participatory manner. It is therefore essential to co-design and co-implement site- and context-specific interventions that create multifunctional landscapes and provide multiple environmental, social, and economic benefits to different users at different scales (Lovell and Johnston 2009).

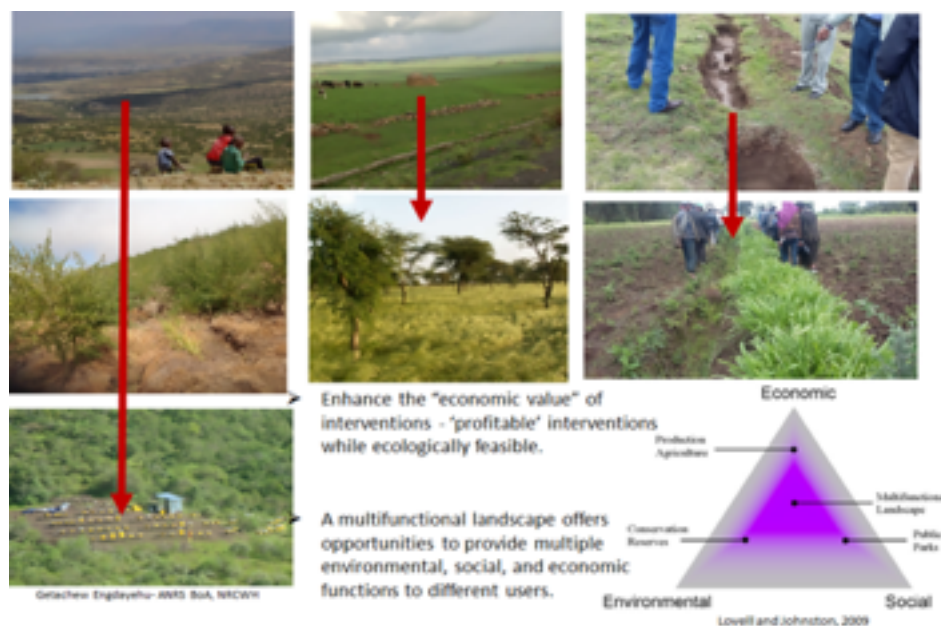
Context

Integrated 'landscape' management work has been implemented in two of the Africa RISING sites: Debrebirhan (Basona, Gudoberet-Adisghe kebeles) and Hosana (Lemo, Jawe kebeles). The dominant farming system of the Gudoberet-Adisghe watershed is mixed crop-livestock production. Cultivated areas and woodlots (dominated by eucalyptus) are the major land use/cover types. During the long rains, wheat, barley, and faba bean are the dominant crops. The major problems facing the area include soil erosion, soil nutrient depletion, and water and feed shortage. Within this watershed, linked land and water management interventions are executed covering an area of about 60 ha. The major crops cultivated in the Jawe kebele include wheat, teff, maize, barley and sorghum. The area has a favourable climate for diverse crops and home garden development. Water and feed shortage and soil erosion are major problems of the area. Complementary water harvesting, SWC and home gardening technologies are implemented covering an area of about 40 ha.

Description of the intervention: approach/technology

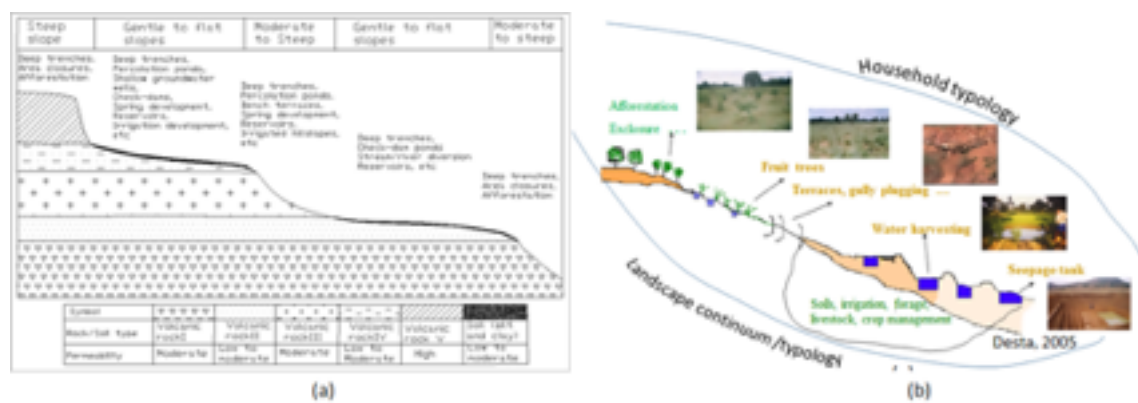
In an environment with increasing pressure on ecosystems due to human population growth and climate change, it is essential to design management measures that provide multiple benefits. Creating multifunctional landscapes entails implementing interventions that can support a multitude of users with minimum conflicts (Lovell and Johnston 2009). It is thus essential to implement site- and context-specific interventions that consider the landscape continuum and satisfy diverse socio-ecological conditions (Figure 1). If implemented wisely through detailed analysis of an option-by-context matrix, the interventions will not only be economically feasible but also socio-culturally acceptable and ecologically sound.

Figure 1: Towards increasing multifunctional landscapes to derive multiple benefits.



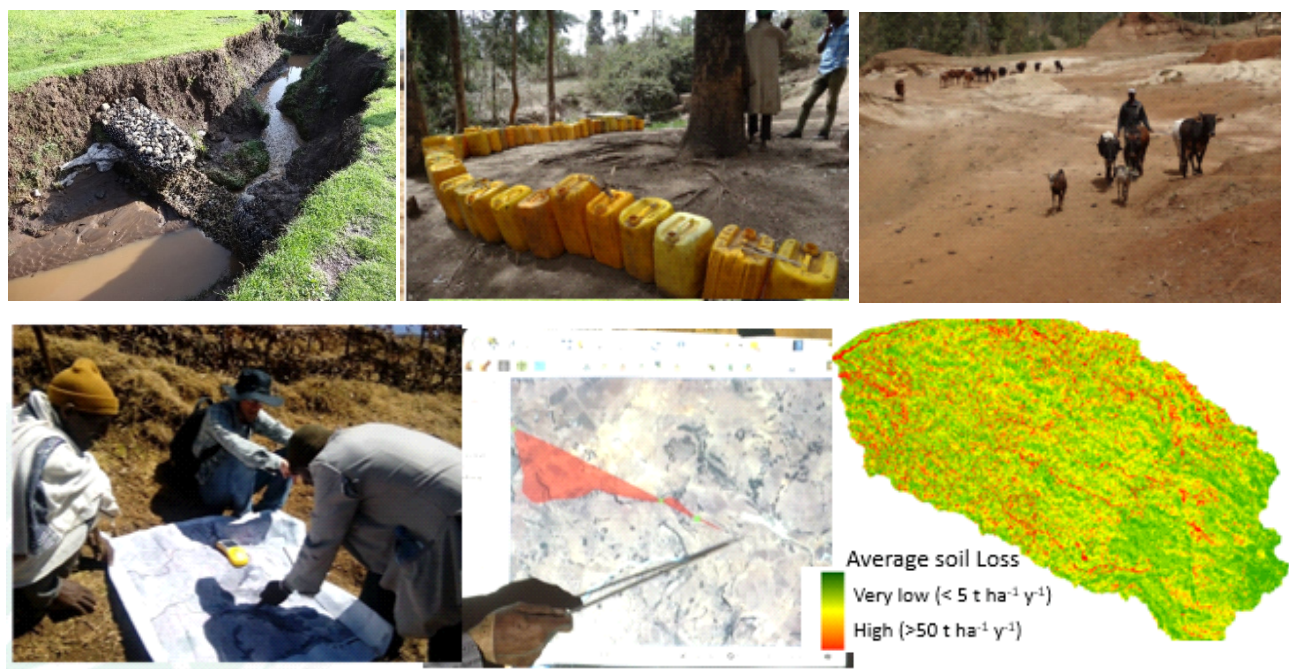
In the Africa RISING project, we not only co-identified and co-implemented SLWM options that can produce multiple benefits but also developed frameworks, approaches and tools that facilitate implementation of a host of interventions across landscapes (Figure 2). Some of the approaches will be instrumental when identifying and implementing context-specific complementary technologies as well as scaling out to appropriate sites. Creating multifunctional landscapes through implementation of complementary options will facilitate synergies while managing tradeoffs between different uses. Our approach considers the landscape in an integrated manner in order to understand interactions, feedbacks and trade-offs and implement interventions that strike an appropriate balance between social, environmental and economic concerns (Sayer et al. 2013).

Figure 2: (a) Analytical model to match options with context and facilitate scaling out appropriate land and water management options, and (b) site-specific interventions across the landscape consortium.



We followed key steps when implementing linked technologies that promote synergies and provide multiple benefits. The first step involved co-problem identification (‘what problem where’). This was achieved through transect walks, participatory resources and constraint mapping, focus group discussion and modelling (Figure 3). This exercise helped us to understand the real problems at each site and informs the interventions required.

Figure 3: Co-problem identification and mapping through various approaches.



The next step involved capacity development of stakeholders (farmers, extension agents, members of the Bureau of Agriculture and local and regional administration) through training, exchange visits and experience sharing. Here, it is important to note that involving all stakeholders in the capacity-development exercise was useful as implementation of complementary technologies requires involvement and commitment not only from local communities but also the extension, Bureau of Agriculture as well as kebele and district-level administration.

In addition to co-planning and implementation, evaluation of the status and impacts of interventions in a participatory manner was essential. Field visit, participatory and modelling approaches were used to evaluate the status of interventions and assess their impacts (Figure 4). Evidence was generated through modelling and measurements. In this project, we presented the observed results to the local community and co-analysed the impacts of different scenarios, which attracted great interest.

Figure 4: Co-implementation and monitoring of land and water management interventions.



Results

Table I summarizes the major outputs, outcomes and impacts achieved during phase I of the Africa RISING project. Though it will not be possible to isolate impacts realized due to ‘landscape’ related interventions only, we included some we think would not have been achieved had the landscape work not been implemented (see Table I).

Table I: Major outputs and outcomes associated with key activities in the Debre Birhan and Hosanna sites of the Africa RISING project in the Ethiopian Highlands

| Activity | Output | Outcome | Impact |
|---|--|---|--|
| Co-identify and implement linked technologies | Tool, framework to align interventions to specific location | Stakeholders and planners become efficient in matching ‘problem to solution’ | Over ten linked technologies implemented |
| Capacity development | Farmers, extension/development agents, university lectures, kebele and district level administrators trained | Stakeholders become aware of the benefits of aiming to create multifunctional landscapes that can promote synergies | Trained 150 farmers, four graduate students and two doctoral students |
| Evidence generation | Plot and landscape level information on runoff and sediment use across different land use/cover types and management options | Stakeholders have clear information on differences in soil loss and crop yield reduction due to integrated landscape management | Stakeholders recognize impacts of interventions, this enhanced their technology adoption |
| Ex-ante analysis | Tool developed to analyse the potential impacts of different SLM/SWC interventions at landscape scale | Stakeholders evaluated the impacts of interventions and assessed what it means to them with regards to areas affected | Easy to use tool helped quick ex-ante analysis |

| Activity | Output | Outcome | Impact |
|------------------|---|--|--|
| Tool development | Modelling framework and tool developed to assess the multiple benefits of integrated interventions | Stakeholders gained information on which interventions placed where can provide dual benefits (e.g. reduce erosion and improve baseflow) | Can facilitate tool development to assess impacts of interventions on ecosystem services |
| Exchange visit | Stakeholders understood role of integrated land and water management practices; adopted lessons to their respective sites | Significant behavioral change of participants, planners and decision- makers at the different sites | Experiences shared between communities Africa RISING rated highly |

Key lessons and challenges

Though interventions are planned to be complementary and provide multipurpose benefits, the gains are long-term and economic returns are not visible for local farmers. It is thus essential to provide incentives in the form of inputs. In some cases, communities have many problems and expect much from projects.

Some of the key lessons include the benefit of experience sharing through exchange visits. For example, the visit to Tigray inspired many farmers and enabled them to implement options. This included construction of ponds for water harvesting and irrigation. The fact that the interventions were planned and implemented in a participatory manner also gave farmers the confidence to be engaged in technology implementation. Our experience also shows that identifying and implementing linked technologies across the landscape continuum is essential to both restore degraded areas and generate multiple benefits.

Implications for scaling out

The analytical framework used to match ‘options with context’ will form the basis to create ‘recommendations domains’ within which technologies will be scaled. The review related to successful sites clearly showed the institutional and policy set-ups that are necessary to successfully implement interventions. This will be a good basis for consideration during scaling out. Our approach involved stakeholders starting at the grassroots (local farmers) to extension, development agents, kebele administration, Bureaus of Agriculture, universities and engagement of officials at zonal level. This is crucial to gain support when scaling options both horizontally and vertically. The fact that we have buy-in from planners and policymakers is also essential. ‘Natural resources management’ is one of the key agendas of the Ethiopian government under GTP II; this commitment will facilitate the scaling out and up of suitable technologies. Project support will be instrumental in capacity development, evidence generation and provision of key inputs. In order to incentivize stakeholders, it will be essential to devise mechanisms/strategies to enforce ‘payments for ecosystem services’.

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Drip irrigation and service provision of irrigation water: new ways to step into affordable small-scale irrigated agriculture

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Introduction

Irrigation development is critical in the face of climate change-induced water scarcity and the current endeavours in Ethiopia to transform agriculture. The literature supports the benefits of irrigation on poverty and food security (Namara et al. 2010; Burney and Naylor 2011; Hagos et al. 2012). The literature indicates the advantage of using drip irrigation on water use efficiency and reports a positive impact on the environment compared to other irrigation methods such as furrow or overhead irrigation (Burney et al. 2010; Levidow et al. 2014). However, the use of drip kits implies that a water source is available as well as labour/technologies to fill these tankers. In many cases, water resources might be either very remote or technologies are not present to fill these tankers resulting in manual labour needs.

When water is not locally available, transporting water by multipurpose tractor, for example, storing it in a tanker before it is applied to crops and using drip kits could be attractive. Whether this is economical is a crucial question. There is no evidence that demonstrates the economics of water delivery; this study attempts to fill this research gap. A combination of drip and water delivery is considered.

This study compared crop and water productivity of high value-crops under drip irrigation to the common practice (farmers using buckets to apply water to crops) in Lemo district, and the economic feasibility analysis compared drip irrigation to control. The study assessed the economic feasibility of drip irrigation vs. farmers practice by accounting costs of water delivery (both labour and fuel) and the value of water. We calculated the cost of water delivery by varying distance to water source less than 0.5, 0.5–1 and above 1 kilometre (km). This exercise was useful because it may help us to define the threshold for economic feasibility. The final scenario was to assess if drip irrigation is still feasible when the household accounts average costs of water delivery and estimated value of water. Finally, the study explored the business environment such as credit provision and other support services that will help the uptake and out scaling of this technology.

Context

The Lemo Gilgel Gibe is a subbasin of Omo Gibe basin, one of the twelve basins of Ethiopia, located in the SNNP Region. Lemo Gilgel Gibe subbasin is found between 7°25'55" and 7°37'41" latitude and 37°37'55" and 37°52'48" longitude. The Upper Gana and Jawe micro watersheds are two out of 26 micro watersheds found in the Lemo Gilgel Gibe subbasin. The Upper Gana micro watershed, named after the kebele, has an area of about 1,946 ha and is located between 7°31'55" and 7°33'54" latitude and 37°40'48" and 37°45'58" longitude and has an elevation from 2,061–2,559 m a.s.l. The Jawe micro watershed, also named after the kebele, has an area of about 1,024 ha of land and is located between 7°30'54" and 7°25'55" latitude and 37°45'29" and 37°49'12" longitude with an elevation ranging between 1,900–2,700 m a.s.l. The Upper Gana and the Jawe micro watersheds together cover about 2,971 ha and comprise 7.2 % of the total area of the Lemo Gilgel Gibe subbasin.

From the analysis of ten years of data (2005–14, source: National Meteorological Agency, Hossaena station) the mean daily maximum temperature ranges from 20.1 °C to 25.3 °C, mean daily minimum temperature ranges from 8.5 °C to 12 °C, mean annual rainfall in the area about 1,161 mm and the maximum mean monthly rainfall of 180 mm occurs in July.

The major rainfed crops produced in the area are enset, wheat, barley, faba bean, teff and potato during the rainy season, and irrigated tomato, potato, cabbage and beet root during the dry season. Main livestock feeds are crop residues, enset leaves and naturally occurring grasses. Soil ranges from red loamy clay at the hill slopes in eroded fields to dark brownish-black fertile soils in the valley bottoms (Kuria et al. 2014).

Description of the intervention: approach/technology

Experiments were carried out in Lemo district, in Upper Gana and Jawe kebeles (PAs) in Ethiopia. The drip kits are part of the CIMMYT protocol in Africa RISING where water is delivered by a service provider using the tractor-mounted pump, transporting water via a trailer (Figure 1). The drip kits were obtained from International Development Enterprises (iDE) and installed for six farmers (three in Jawe and three in Upper Gana) in February 2016 to irrigate a 100 m² plot divided into two subplots: cabbage and carrot (i.e. 50 m² each). The drip kits included two metal tanks of 215 liters each raised about 1.5 m above the ground that supplied water to drip tubing laid on the soil surface. iDE installed the systems. During installation, participating farmers were trained on how to install, operate and maintain the drip irrigation system. A service provider with a motor pump and 400 litre tank mounted onto a tractor supplied the drip farmers with water from a nearby stream whenever it was needed.

Figure 1: Example of the implemented drip kit (left) and service provider with tractor-mounted pump (right).



As understanding the economics of water delivery is critical, the study collected fixed costs (i.e. establishing drip irrigation), farm costs like labour, seed, agrochemicals (fertilizers, pesticides/insecticides), cost of land, cost of water delivery (both labour and fuel) etc. To collect the relevant data from Lemo, we developed a field data book which was used to register the day-to-day inputs to grow two crops until harvest and sale. We collected village-level data like daily wage, female and male labourers, land rental cost and sale prices of inputs, including agro-chemicals, and outputs. Additionally, the amount of water used throughout the season was quantified for each of the crops as well as fuel consumed for the filling and transportation of water to the drip kits. Moreover, we conducted household surveys within the framework of the Innovative Lab for Small Scale Irrigation in Ethiopia (ILSSI) project survey in May–June 2016. We drew from lessons, especially regarding credit service in relation to irrigation technologies.

Results

Crop and water productivity analysis was carried out. Results analysis indicated that (see Table 1) productivity was significantly higher under drip irrigation compared to farmers' practices (controls).

Table 1: Crop- and water-productivity of the planted crops in Upper Gana and Jawe

| Variable | Uper Gana | Control | Jawe | Control | Sig-test (p-value)* |
|----------------------------|------------|-----------|------------|-----------|---------------------|
| Cabbage crop productivity | 60 t/ha | 41 t/ha | 62 t/ha | 44 t/ha | 0.05 |
| Carrot crop productivity | 68 t/ha | 38 t/ha | 65 t/ha | 35 t/ha | 0.05 |
| Cabbage water productivity | 15.5 kg/m3 | 8.7 kg/m3 | 13.3 kg/m3 | 8.6 kg/m3 | 0.05 |
| Carrot water productivity | 14.4 kg/m3 | 6.8 kg/ha | 11.8 kg/m3 | 7.2 kg/ha | 0.05 |

Source: farm book 2015/16; *Significance difference between drip and control

The discounted financial analysis measures showed that drip irrigation is feasible in both Upper Gana and Jawe, more feasible in Upper Gana than Jawe. Growing cabbage and carrot is financially feasible under farmers' practice indicating the importance of supplementary irrigation to meet the water needs of the crops during periods of insufficient water or no rainfall. The financial analysis also indicated that drip irrigation is feasible even if households are required to cover the cost of water delivery both in Upper Gana and Jawe. Farmer willingness to cover costs of water delivery during the current irrigation season is a good example for out scaling the technology.

Table 2: Cost-benefit analysis of drip irrigation in Upper Gana

| | Drip | Control | Drip + Cost of water delivery | Drip + Cost of water delivery + Value of water |
|----------------|---------------------|--------------|-------------------------------|--|
| Discount rates | Discounted benefits | | | |
| 8% | \$160,339.65 | \$120,152.79 | \$152,433.52 | (\$16,248.96) |
| 12.25% | \$137,584.38 | \$140,146.21 | \$130,758.99 | (\$14,865.13) |
| 16.60% | \$118,999.85 | \$120,023.83 | \$113,058.78 | (\$13,697.92) |
| IRR | 499% | 162% | 476% | |

Source: farm book 2015/16

However, including the value of water in the cost-benefit analysis makes drip irrigation unfeasible. Both discounted net benefit measures, net present value and internal rate of return values, indicated that drip irrigation is not feasible when the value of water is included in the cost-benefit analysis. Thus, charging farmers a water fee doesn't make economic sense.

Table 3: Cost-benefit analysis of drip irrigation in Jawe

| | Drip | Control | Drip + Cost of water delivery | Drip + Cost of water delivery + Value of water |
|----------------|---------------------|--------------|-------------------------------|--|
| Discount rates | Discounted benefits | | | |
| 8% | \$42,912.14 | \$168,811.87 | \$121,810.42 | (\$10,142.08) |
| 12.25% | \$105,875.27 | \$182,316.82 | \$104,321.97 | (\$9,593.04) |
| 16.6% | \$91,399.05 | \$266,130.26 | \$90,047.00 | (\$9,108.89) |
| IRR | 390% | 165% | 385% | |

Source: farm book 2015/16

The impact of these technologies on household poverty in Lemo and other sites in Ethiopia is currently being analysed by the ILSSI project. The evidence is indicative that these technologies could be scaled out to similar smallholder farmers in Lemo and elsewhere.

Key lessons and challenges

When the drip technology was tested during the dry season, several opportunities and challenges were reported. After some delay in installation, the farmers appreciated the water application efficiency and reduction in labour input. They noted a uniform application of water compared to the bucket technology. This was confirmed by the technology calibration which indeed showed a relatively uniform application rate along the various drip lines. Farmers also noticed a reduction in weed production.

The delivery of water by the service provider reduced farmer labour input. However, the water service provision presented some challenges. Even with considerable training, the service providers were not able to operate the tractor as well as its mounted pump. This was particularly the case in one kebele, hence the activity was taken over by the project assistant. Furthermore, the connector between the tractor and trailer broke. Farmers were forced to go and fetch water at the river (which ranged between 0.2 to 1 km) using donkeys and other transport mechanisms during that time. There were some challenges with respect to maintenance of both the tractor, its mounted pump and the drip kits despite frequent training by researchers, field assistants and the supplier.

Implications for scaling out

The crop and water and cost-benefit analyses indicate that both drip irrigation and water delivery service is economically feasible. The results are indicative that farmers are willing to adopt drip kits and its accessories and are willing to pay for the water delivery service.

There are various local organizations, like iDE and Bruh Tesfa, supplying drip kits and accessories of different sizes, designed according to the demand of farmers. Getting adequate supply for out scaling is not a problem if the supply is linked with microfinance services.

There are good experiences in Lemo by ILSSI (another FtF initiative project) providing seed money for credit in promoting small-scale irrigation, although some challenges are witnessed with the repayment, to provide irrigation technologies and in Kenya where suppliers are making arrangements with microfinance institutions to out scale solar irrigation technology. The presence of credit packages for irrigation technologies by most of the microfinance organizations in Ethiopia is a good opportunity for horizontal out scaling.

A 2016 study by ILSSI reported that close to 68% of the households have applied for a loan last year. The mean loan acquired was about ETB16,000. Major credit sources are microfinance institutions (76.32 %), followed by friends/relatives (4.22 %) and farmers groups (3.73%). Loans requested were for oxen purchase (32.30%), purchase of farm inputs such as improved seeds and agro-chemicals (24.72 %), health expenses (19.45%), small-scale irrigation (17.96 %) and for other/nonagricultural businesses (3.42 %). These results indicate that microfinance institutions are one of the relevant stakeholders for out scaling new technology such as drip technology.

The provision of irrigation water service delivery is new in Ethiopia. Cooperative societies and private investors are potential target stakeholders to engage in the business. The current study showed the economic attractiveness of irrigation water provision service from the farmer's point of view but the feasibility of water provision as a business, from the supplier side, needs further enquiry.

Another related issue is shifting from two-wheel tractors to heavy-duty tractors, in the view of accommodating farmers' demand to irrigate more land and demand for larger water tankers, requiring larger investment capital. One of the packages by the Development Bank of Ethiopia meets this demand provided there is demand from cooperative societies and private investors. This could be a good condition for vertical scaling out. Scaling out this technology requires the involvement of various stakeholders, namely, farmers, local administration, microfinance institutes and the Development Bank of Ethiopia. The project provided a basis for continued stakeholder networking.

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Crop varieties research and implications on closing yield gaps and diversifying incomes: Africa RISING experiences

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Introduction

Agriculture is the most important sector of the economy of Ethiopia and accounts for about 45% of the GDP, 90% of exports and 85% of employment. Nutrition of both human and livestock, nevertheless, remain a key challenge to the government of Ethiopia. The Highlands of Ethiopia (>1,500 m a.s.l.) cover over 40% of the country's total land area and are home to over 80% of the total human and cattle populations. The production systems in the Central and Northern Highlands predominantly consist of mixed cereal-legume-potato. The livelihoods of the smallholder farmers in these Highlands rely on the production of barley (food and malt barley), cool season food legumes (faba bean, field pea and lentil) and potato.

Cereals, cool-season food legumes and potato are produced during the main (meher) and small (belg) rainy seasons in the Highlands of Ethiopia. The small rainy season (rainfed and irrigated) covers 4% of the cultivated areas in the country. The production of barley, faba bean, lentil, field pea and potato during the small rainy season helps poor farmers in Highlands to bridge the three to four months (June-September) food and feed gaps until the main season harvest is available. Potato is particularly important for food and income generation for poor farmers in the Highlands, especially in women-headed households. In past years, cool season food legumes and potato have gained a lot of importance as food, feed and generators of cash incomes for smallholder farmers. The legume component improves system productivity through N fixation, serving as a break for insect pests, weeds and disease cycles affecting wheat, barley and potato. In addition, integration of potato in cereal and legume-based farming will boost plant and soil health as well as productivity.

Context

Despite an ideal environment for these crops production in the Highlands, crop yields are typically very low (less than 2 t/ha for cereals and legume, and 8 t/ha for potato). However, smallholder yields can realistically reach 4–6 t/ha for cereal and legumes, and 35–60 t/ha for potato. This yield gap highlights a significant opportunity to increase productivity and overall production. Major constraints to cereal, legume and potato production in Ethiopia include a shortage of improved crop varieties, shortage of good quality seed tubers, lack of local seed system capable of producing high-quality seed, suboptimal production practices and limited storage facility, and lack of adaptable and disease resistant varieties.

Description of the intervention: approach/technology

The following activities were undertaken to address the above-mentioned bottlenecks.

Demonstration and selection of improved varieties

High-yielding improved varieties of cereal (bread wheat, durum wheat, food and malt barley), cool season legumes (faba bean, lentil and field pea) and potato were demonstrated in farmers' fields. Local varieties were also included as a check or control. Demonstration of high yielding farmer- and industry-preferred cereal, food legume and potato is

a major commitment to close the yield gaps and diversify the wheat-based cropping system in the four Africa RISING sites. The cultivars of improved varieties were the released cultivar or variety by the national research systems.

Decentralized system for community-based seed production and extension provision

Demonstration and participatory variety selection of barley, faba bean, wheat and potato have identified new farmer and industry-acceptable crop varieties. Functional seed systems via decentralized community-based seed production and extension provision were built around these selected varieties to increase the availability of quality seeds for increased agricultural productivity in the four Africa RISING sites (Figure 1).

Figure 1: Local seed multiplication approach for accessibility of seed to local smallholder farmers.



Postharvest storage of seed potato is very important to maintain the shelf-life and quality of planting material. Farmer acceptable and improved seed storage technology for potato (diffused light storage (DLS)) was piloted at all four Africa RISING sites during the 2014–15 cropping season.

Implementation process or approach

On-farm, participatory variety selection of cereals included bread wheat, food and malt barley, durum wheat, cool season legumes (faba bean, lentil, field pea) and potato along with good agricultural practices were conducted in Lemo, Bale, Debre Birhan and Mekele (2–3 model farmers/kebele/site, in total two kebeles per site) during *belg* and *meher* seasons 2014–15. Mid- and end-season evaluations were conducted during crop flowering and harvesting time where neighbouring farmers, extension agents, and woreda and regional officers as well as industry people were invited. Varieties were collectively ranked and rated based on their performance, disease and lodging tolerance, earliness, grain/tuber yields and biomass.

Community based-seed production and extension provision were built around these selected varieties to increase the availability of quality seeds for increased agricultural productivity in the four Africa RISING sites. Two to three model farmers per kebele/site and two kebeles/sites per crop were selected for this activity. Since seed production is a technical and intensive process, model farmers were trained on good agricultural practices for seed production and handling. Extension workers, farmers, MoA, development agents, innovative platform members, stakeholder institution representatives and interested farmers were involved in the planning and implementation of field days for the community seed production trials. Training was given on different agronomic practices via three farmer field schools. Farmers also received training on different agronomic practices on seed potato production, and were trained on the planting, earthing-up, dehulming, and harvesting operations of seed potato production. Both male and female farmers participated in the training; however, youth and male participants dominated the sessions.

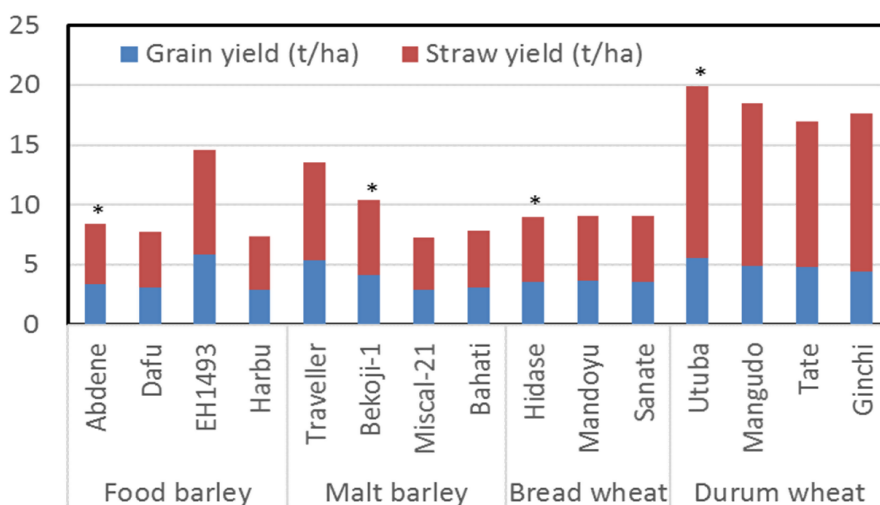
DLS technology was demonstrated by sharing the constructing cost of the DLS (i.e. farmers contributed wood from Eucalyptus trees and unskilled labour, and the project contributed industrial material such as corrugated iron sheets, iron nails and skilled labour/carpentry). Training on DLS was given to farmers by bringing them in a group to farmers who already had DLS technology.

Results

Participatory selection of cereal varieties: Improved cereal varieties had higher grain yield and biomass as compared to the local varieties (Figure 2). Farmers selected improved crop varieties and technologies will lead to narrow grain and biomass yield gaps.

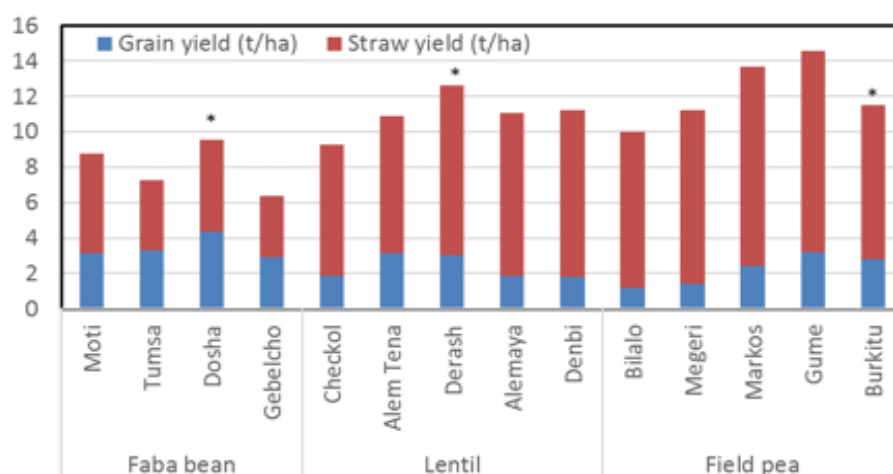
- Food barley cultivar Abdene was selected because of its early maturity and high yield.
- Malt barley cultivar Bekoji I was selected because of its early maturity and performance.
- Bread wheat cultivar Hidase was selected because of performance, yield and resistance to rust.
- Durum wheat cultivar Utuba was selected because of performance, yield and resistance to rust.

Figure 2: Participatory selection of cereal variety.



*Represents the varieties selected by farmers

Figure 3: Participatory selection of cool season legume varieties.

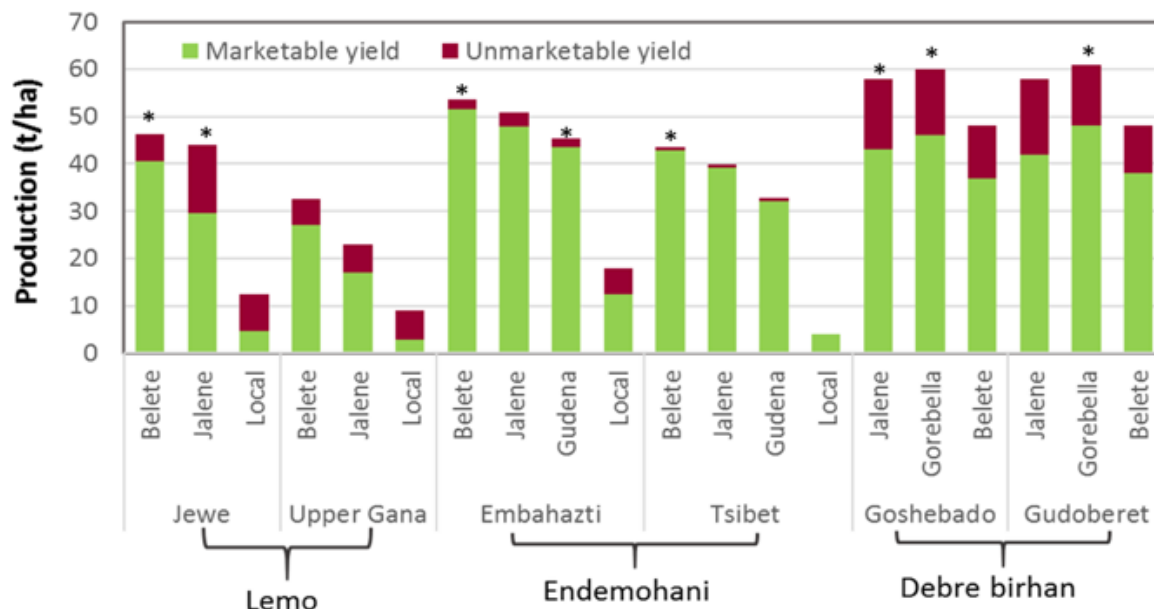


*Represents the varieties selected by farmers

Participatory selection of cool season legume varieties: Improved cool season legume varieties had higher grain yield and biomass as compared to the local varieties (Figure 3). Farmers selected improved cool season legume varieties and technologies will lead to narrow grain and biomass yield gaps.

- Faba bean cultivar Dosha was selected because of yield, performance and high biomass.
- Lentil cultivar Derash was selected because of performance and high biomass.
- Field pea cultivar Burkitu was selected because of its high yield, grain colour and resistance to chocolate spot.

Figure 4: Participatory selection of potato varieties across Lemo, Endemohani and Debre birhan.



*Represents the varieties selected by farmers

Participatory selection of potato varieties: Farmers selected improved potato varieties because of high yield, earliness, less cooking time and late blight tolerance. These improved varieties yielded up to seven times higher than the local variety (Figure 4). Farmers at Lemo selected Belete and Jalene. Similarly, Belete and Gudane were selected in Endemohani. In Debre birhan, Gorbella was preferred because of its ability to perform under very cool weather conditions.

Picture 1: DLS at Lemo. This will increase the availability of quality seed used for planting by farmers, resulting in higher yields per unit land area.



DLS capacity increased to 240 t (Figure 5). After harvesting, seed potatoes were stored in DLS. For faba bean seed storage, triple bags will be promoted and distributed to faba bean community seed producers. DLS was found to be the most efficient practice to overcome the storage problems of potato seed material by farmers, who were unaware of DLS before the project started; prior to project implementation, potato seeds were stored under the bed or in the backyard and until sprouted. Participants are satisfied that the project promoted the idea of constructing DLS by sharing costs. Farmers who constructed DLS sold 50–80% of potato seeds to neighbouring farmers and planted the rest for themselves. Now these seed producers are considering the establishment of a small-scale seed business by forming a seed cooperative.

Key lessons and challenges

The project demonstrated that crop diversification ensures sustainable production. In addition, farmer and industry participation in variety selection speed up adoption of new technologies while **working in partnership enhances technology selection and promotion.**

Informal seed multiplication and delivery enhance technology adoption. Field days and IP create unique opportunities for knowledge and information exchanges.

Implications for scaling out

Farmer's selected cereal, cool season legume and potato varieties along with their recommended production packages, including the DLS, will be promoted to increase productivity and production. This will help to close yield gaps, increased food security and income.

Decision support tools for farm-level fertilizer recommendations in Ethiopia

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Introduction

One of the major limiting factors for low crop yield is the soil fertility decline in Ethiopia. Farming in the wheat-based systems areas has been small scale, low input, low output, whereby farmers rarely apply sufficient amount of chemical fertilizers. The average fertilizer consumption in the regions varies from 42–55.7 kg per ha, until recently with only urea and ammonium sulphate available to the system.

Context

There is now increasing agreement among the research and development communities on the need to apply optimum amounts of mineral fertilizers not only to increase crop yield per unit of land but also to reduce the risk of opening up new land to farming at the expense of wetlands, forests and other protected areas. However, in areas where farmers do apply higher rates of mineral fertilizers, farmers rarely get positive crop response and economic incentives. Increasing application of N and P fertilizers in the Ethiopian Highlands did not assure increased wheat productivity, which could be partly due to the unbalanced fertilization exacerbated by the limited range of fertilizer blends that are available in the country or by inherent soil properties and poor targeting of landscapes.

Description of the intervention: approach/technology

Through our previous research in Africa RISING and other projects, we have an extensive understanding of the Ethiopian Highlands and have already collected a wide range of information on ‘what is missing where’. To give some examples on nutrient types required for specific landscapes: 1) we will promote N and P fertilizers to be used across farms and systems throughout the Ethiopian Highlands but reduce the recommendation rate by 30% in valley bottoms, hillsides and homesteads; 2) we will promote application of potassium fertilizers mainly in areas dominated by red Nitosols and where horticultural crops and enset are the major commodities; 3) we will promote application of sulphur only in areas where land degradation is apparent, pH is relatively high and organic matter content of soils is low; 4) we will promote application of zinc only in areas where soil fertility is relatively good, and higher NPK (Nitrogen, Phosphorus and Potassium) application is commonly practised. Our major recommendations for degraded landscapes, with higher slopes, are interventions to improve soil water-holding capacity through green manuring, application of organic fertilizer including compost, conservation agriculture and minimum tillage before chemical fertilizers are applied.

Through the support of the feed-the-future program, Africa RISING, we have conducted multi-location experiments in the Ethiopian Highlands to identify the most yield-limiting nutrients across landscape positions and farming systems and assess the yield benefits of application of various combination of nutrients (Table 1) in various slopes and landscape positions. The experiments were conducted in four districts in Ethiopia, namely Lemo, Bosena, Sinana and Endamohoni districts in the Hadiya, North Shewa, Sinana and Southern Tigray Zones, respectively.

Table 1: Fertilizer combination and rates used for the on-farm experiments

| Treatment level | Fertilizer combination | Urea (kg/ha) | DAP (kg/ha) | Potassium nitrate (kg/ha) | Potassium sulphate (kg/ha) | Zinc sulphate (kg/ha) |
|-----------------|------------------------|--------------|-------------|---------------------------|----------------------------|-----------------------|
| T1 | N, P | 151 | 161 | 0 | 0 | 0 |
| T2 | N,P,K | 117 | 161 | 162.5 | 0 | 0 |
| T3 | N,P,K,S | 151 | 161 | 0 | 163 | 0 |
| T4 | N,P,K,S,Z | 151 | 161 | 0 | 163 | 24.5 |
| T5 | Control (33% NP) | 49.8 | 53.1 | 0 | 0 | 0 |

Results

There is a significant difference in grain yield between locations; grain yield in Endamhohoni is significantly higher than in Lemo. The yield gap caused by nutrient deficiencies was the highest in Endamehoni, with 53.4% in 2015 and the lowest in Lemo with 37.4%. In some locations, the yield gap in between hillslopes and foot slopes could reach to about 7 t. In general, yield gap was significantly affected by landscape positions rather than fertilizer treatments ($P < 0.01$). Treatment effects were highly pronounced when crop yield at various landscape positions was considered. Grain yield was the highest in foot slopes, followed by mid-slopes across locations. The productivity in the hillslopes was significantly lower than both landscape positions. The yield benefits of application of fertilizers was significantly higher in mid-slopes than either foot slopes or hillslopes, regardless of location. Response to the application of various combinations of nutrients followed a similar trend across locations and years, with low NP (nitrogen and phosphorus) application getting the lowest yield across locations (Amede et al. 2016a; Amede et al. 2016b; Amede et al. 2016c; Amede et al. 2017).

Key lessons and challenges

This study confirms earlier studies suggesting that homogenous management zones could be used as an alternative to grid soil sampling and to develop nutrient maps for variable rate of fertilizer application. Spatially similar areas within fields may be useful in relating yield to soil and topographic parameters for crop performance evaluations.

Implications for scaling out

The implication of this research is that in hillslopes, where crop response to mineral fertilizer is low, there is a need to apply organic resources in terms of manure, crop residues, green manures and other alternative sources that would improve soil organic carbon thereby improving soil water holding capacity and enhancing nutrient and water use efficiency. On the other hand, the foot slopes will keep producing relatively higher yield with application of limited maintenance fertilizer rates. However, we recognize that these recommendations should be modified based on the local situations and farmer yield objectives.

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Feed innovations for improved livestock productivity in the Ethiopian Highlands: Africa RISING experiences

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Introduction

The feed resource base in the mixed farming system of the Ethiopian Highlands has been on decline due to the continual conversion of grazing lands to arable lands and concomitant loss of fertility/land degradation of the remaining pasture lands. This has forced farmers to heavily rely on crop residues for their animals. Reports show that 40–80 % of the diet of ruminants are derived from crop residues particularly during the long dry period when green forage becomes scarce. Heavy reliance on crop residues for livestock nutrition has implications on livestock productivity and sustainability of the mixed farming system in the Highlands. On one hand, crop residues have poor nutritional quality and when fed alone rarely fulfil maintenance requirements of animals. On the other hand, complete removal of residues from crop lands for livestock feeding significantly contributes to the gradual depletion of soil organic matter, low water-holding capacity and subsequent loss of soil fertility of arable lands. For a sustainable improvement in crop-livestock productivity, it is therefore imperative to improve the feed resource base of the mixed farming system in the Highlands by introducing well adapted and high yielding fodder crops and efficient utilization practices.

The federal government of Ethiopia, in GTP II, has given special emphasis to the livestock subsector with the objective of adequately exploiting its potential for rural poverty reduction, food security, growth, export earnings and job creation for youth and women. Improving animal feed resources is one of the main strategies to realize these objectives together with breed improvements and better management of animal health issues.

Currently, the government is also giving due emphasis to soil and water conservation at watershed level throughout the country. Terraces have been built on sloped areas to minimize soil erosion and improve water infiltration into cropping/grazing lands. These physical structures need biological reinforcement to serve their purpose for extended periods and realize their intended benefits. Planting of multipurpose fodder trees and perennial grasses on these niches can create a synergy to protect the environment and at the same time increase the feed biomass available to improve livestock productivity. Thus, integration of forage production in the cropping system has a potential to intensify the mixed farming system, while shaping it to be resilient to climatic shocks.

Moreover, with the development of watersheds, regional administrations have started to develop policy directions and community bylaws aimed at promoting controlled grazing (minimizing free grazing), improving livestock productivity per head of animal (through improved breed and nutrition) and harmonizing herd sizes with available feed resources. To realize these policy directions step-by-step, a long-term forage development plan is needed to ensure adequate feed biomass availability that paves the way for the adoption of a sustainable cut-and-carry feeding system. In this regard, it is important to equip farmers with the necessary skills to manage forage resources and feed livestock according to nutritional requirements and avoid unnecessary wastage of feed biomass while feeding and during storage. This requires building the capacity of farmers and local development stakeholders by providing hands-on training, and easily understandable guide manuals for feed conservation, formulation and feeding for different classes of animals. Forage markets are emerging in different parts of the country and development of the feed and forage value chain is necessary to create alternative income sources for farmers and diversify their means of livelihood. To this end, the Africa RISING project has implemented action research related to feeds and forages with the aim of promoting context-specific feed production and utilization practices that improve livestock productivity and livelihood of communities while at the same time contributing to the environmental sustainability of the mixed farming system in the Highlands.

Context

The Africa RISING project has been implemented in four woredas (Endamohoni, Basona, Sinana and Lemo) located in Tigray, Amhara, Oromia and SNNP regional states. These woredas are predominantly wheat and barley growing areas, where livestock are also an integral component of the farming. Lemo is one of the densely populated areas in the country, with an average landholding of about 0.5 ha; Sinana is a relatively less populated area with a better mechanized agriculture. Enset and other fruit trees are widely grown at the Lemo site, while tree plantations are quite limited in Sinana. The socio-economic condition of the other two sites, Endamohoni and Basona, lies in between Lemo and Sinana.

Description of the intervention: approach/technology

The forage and feed interventions implemented in the four sites were aimed at addressing multiple functions including dry season feed shortages, poor quality of available feeds, natural resource conservation and alternative source of employment and cash income. Towards this end, the interventions included promotion of the cultivation of fodder trees, perennial and annual grasses as well as postharvest handling and utilization practices, as described below.

Fodder from tree lucerne: Tree lucerne is a multipurpose (fodder and soil fertilizer) leguminous tree that grows exceptionally well in the cooler highland areas of Ethiopia, where availability of other legume fodders is limited. Under good management (fencing, manuring and watering), the seedlings of tree lucerne can reach up to 2 m of height and be ready for the first forage cut within nine months of planting. The leaf and edible branches of tree lucerne are very good sources of nutrients for ruminant livestock, containing high amounts of crude protein (20-25%) and digestible organic matter (~70%). The foliage of this fodder can be fed green or preserved in the form of hay and used as needed. In addition to its role as a high-quality feed resource, the plant improves soil fertility by fixing N and produces biomass that can be used for mulching. It does not compete with other crops, and thus is suitable for strip cropping or for natural resource management by planting it on soil bunds. The tree also produces a considerable amount of wood biomass for use as fuelwood. These factors make the tree an ideal agroforestry plant in the mixed crop-livestock farming system. Despite these potentials, however, the tree is not adopted widely, and in areas where it has been introduced, there is a knowledge gap on its management and utilization. Action research on tree lucerne was thus initiated under the Africa RISING project to demonstrate to farmers the potential benefits of this agroforestry tree by giving them the necessary skills, from raising seedlings to managing and utilizing the tree for livestock feed and other purposes. The research also aimed to gather evidence on key determinants of growth and survival of tree lucerne, optimal cutting height and cutting frequency under the local conditions, and optimal supplementation to improve the nutrition of ruminant livestock consuming low-quality crop residues.

Supplementary forage from rainfed/irrigated oat-vetch mixtures: Oat is a fast, upright growing annual grass that has a potential to produce significant forage biomass within two months of planting, reaching more than 1 m height under good moisture conditions. The plant grows well in high- and mid-altitude areas of Ethiopia, where the soil is optimally drained and has a pH range of 5.0–6.5. It can also tolerate acidic soils as low as 4.5. Vetch is an annual legume forage which has a similar growing niche to that of oat forage. Growing oat-vetch together (intercropped) has proved to be a suitable feed innovation because of a number of advantages. The intercropped oat-vetch forage produces high quality (energy and protein rich) and quantity forage that can be used as a supplement to locally available feed resources (mainly composed of cereal crop residues) for ruminant livestock. For farmers who need an immediate source of good quality feed, cultivation of oat-vetch mixture is a promising alternative.

Suitable varieties of oat and vetch have been approved and released through the national system. Therefore, production of such forages using supplemental irrigation water or under rain-fed conditions can contribute considerably to the improvement of the feed resource base in the Highlands. In areas where irrigation water is available, cultivation of irrigated forages is not commonly practised for various reasons. Action research on irrigated/rain-fed oat-vetch mixture production was aimed at promoting the value of allocating land and water resources in promoting livestock productivity and income of farmers. The research involved demonstrations, training on the use of

oat-vetch biomass for livestock feeding and generating evidence on the economic contribution of this feed innovation for smallholder farmers.

Desho grass for feed and land stabilization: Watershed management (soil and water conservation) and area closure are some of the large projects initiated by the Ethiopian government as a means to reduce soil erosion and environmental degradation. The physical interventions alone (soil bunds or terraces), however, are observed to contribute little if not accompanied by biological treatments like planting of grasses, legumes and trees on the bunds. These structures (soil bunds) have become important niches to grow forage for livestock and generate additional benefit on top of minimizing soil erosion and improving infiltration. Desho grass has become an effective indigenous grass that grows well on soil bunds. It stabilizes the soil bund through its root system, thereby prolonging the life of the soil bunds. The grass biomass is also useful to compensate for the amount of land farmers lose due to physical structures on their crop lands as the grasses are planted on the bund.

The Africa RISING project initiated a watershed management action research and established model watersheds. On these model watersheds, desho grass has been introduced and evaluated with the objective of promoting its adoption in similar watersheds across the regions through the realization of immediate benefits from its use as forage and source of cash income.

Intercropping forages with faba bean: Farmers in some parts of the Ethiopian Highlands depend on crop thinning and weed outs from crop fields for feeding their livestock during the crop growth season when stored feed stock is depleted and most of the arable lands are covered with crops and stable grazing is not possible. Although this traditional practice of using weeds grown with the faba bean crop produces much-needed forage during the critical period, farmers reported a decline in the quality of weed biomass obtained over the years. Introducing intercropping of faba bean with forages can be an alternative strategy to produce both food and feed biomass from faba bean plots. Action research was initiated to explore the overall benefit that the farmers derive from the traditional (once late weeding) and improved (frequent weeding) of faba bean plots in two of the Africa RISING sites. Screening of competition-tolerant faba beans was also performed by intercropping different varieties with oat forage under irrigation and rain-fed conditions.

Sweet lupine as a feed and food crop: The Highlands of Ethiopia suffer from shortage of land to allocate for food and livestock feed. Intervention with dual/multipurpose crops like sweet lupine, a leguminous food and feed crop that can be grown in well-drained soils (non-Vertisols) in the Highlands of Ethiopia, has proved to cater to diverse needs of the farmer. Adaptation experiments with different varieties of sweet lupine have been carried out in the Africa RISING sites.

Postharvest handling and utilization of feed resources: Diagnostic studies revealed that the local practice of storage and utilization of dried feed resources, mainly crop residues, incurs a considerable level of wastage that otherwise could be used to cope with dry season feed shortages. To minimize postharvest wastages and quality deterioration of feed resources, Africa RISING implemented action research aimed at demonstrating improved postharvest feed handling technologies including feeding troughs, storage sheds and feed processing techniques. The research was designed to generate evidence on the potential benefits of the technologies for individual farmers and the economic feasibility of the investment on such technologies. To achieve these objectives, designs were developed and prototype troughs and sheds constructed on selected farmers' premises, through which farmers were allowed to evaluate the local and improved practices and data were generated.

Implementation of the various action research was done through IPs established at the four sites at woreda and kebele level. The IPs were formed by engaging relevant development actors working in the area, including experts from woreda and zonal sector offices, research centres, universities, NGOs, the private sector and farmer representatives. Research protocols were developed for each action research; they were presented to the IPs, discussed and evaluated for their relevance. After approval by the IPs, FRGs were formed in each kebele for each of the research protocols. The size of FRGs was limited to 20–30 households and selection was based on interest, capacity to implement the research and willingness to serve as a model farmer to demonstrate the technology being tested to other farmers.

Participant farmers contributed lands, inputs and labour to the trials while Africa RISING brought the forage species and technologies to be tested. Implementation of the research was preceded by training. Data collection was performed by enumerators hired by the project. Results of the action research were presented and evaluated among FRGs and IPs.

Results

More than 600 farm households participated in feed and forage related-action research across the four sites over three years. Some of the households participated in three or more research protocols, while the majority participated in one or two protocols. The baseline survey conducted at the beginning of the trials indicated that most of the participant farmers (80%) had little experience of improved forage cultivation for livestock production. An important achievement of the action research was the awareness created among farmers about the importance of cultivated forages and feeding practices to improve livestock productivity. Farmers acquired skills on cultivation and utilization of feed resources through training, active participation in the research and field days organized at the end of each crop growing season.

The increased awareness and skills translated into high demand for forage planting material (seedlings, seeds) and allocation of relatively large areas of land for forage cultivation. Initially, farmers experimented on small plots (10 × 10 m), but later, they developed confidence and became willing to allocate more land (for instance, up to a half ha in Sinana) for forage production. The forage trials showed the possibility of producing a high amount of good quality forage from a limited plot of land.

The action research on tree lucerne showed that in well-managed farms, it is ready for use as animal feed within nine months after planting. Seedling survival and growth were highly dependent on early management and farm typology. Management practices like manuring, watering and fencing significantly improved the survival and growth of tree lucerne under farmers' conditions. Medium-resource farmers were found to manage tree lucerne in a better way than poor or resource-rich farmers. A cutting height of 1.5 m above the ground and a cutting frequency of 2–3 times per year were found to provide better results, with a potential of producing 5–7 t DM fodder biomass per ha under farmers' management conditions (Mekonnen et al. 2017). Inclusion of tree lucerne leaf in the diet of sheep at up to 50% of the total DM intake produced superior growth performance (weight gain of 70 g/day for Menz rams) without any adverse effects (Mengesha et al. 2017). The tree lucerne leaf supplementation trials indicated its potentials to replace concentrates in providing the required nutrients (protein and energy) for optimal ruminant animal performance.

Oat-vetch forage intercropping enabled farmers to produce a substantial amount of biomass under rain-fed conditions and with irrigation (more than 11 t DM/ha). The oat-vetch biomass produced contained on average 16% of crude protein and 9.67 MJ/kg DM, which was highly favoured by farmers to supplement the diet of fattening sheep, dairy cows and draught oxen. For instance, the feeding observation in the research sites revealed that supplementation of 1.5–2.0 kg DM of oat-vetch hay daily to lactating cows increased milk yield by about 60%. In addition, from desho grass planted on soil bunds, farmers were able to harvest forage 3–4 times per year and produce 4.0–5.5 t DM/ha, depending on the rainfall availability. The grass was found to have good nutritional quality with 11% crude protein and 7.9 MJ ME/kg DM. Desho grass can easily be propagated using root splits with an almost 100% survival rate in the Highlands and serve multiple purposes in the Highlands.

Intercropping faba bean with forages increased forage biomass yield by about 55%, with a slight decline in grain yield (6%), but an increase in overall benefit when the value of both the forage and grain are combined. The results highlighted the potential of improved forage faba bean intercropping over the traditional practice of using ad hoc weed forage intercrops to improve whole-farm productivity. In addition, adaptation trials with sweet lupine as a dual-purpose crop showed that it can provide 1.7–2.6 t/ha of grain, which can be used as a supplement for animals and food for humans.

Currently, there is a widespread disease problem with faba bean and field pea crops. Inclusion of sweet lupine in the cropping system appears to be a useful integration to break disease cycles and offer alternative pulse grain for different purposes. Among the four sweet lupine varieties tested, Sanabo and Vitabor were found to perform very well in the Africa RISING sites.

The use of improved wooden feeding troughs and storage sheds were found to reduce wastage of crop residue and other feed resources by 30–50%. Moreover, feeding troughs reduced the labour demand for feeding animals by 10–20%. The cost benefit analysis showed that the investment on feeding troughs and sheds is economically feasible, with a short cost recovery period (less than one year for feeding troughs) (ILRI et al. 2017). In general, the action research demonstrated that the potential for increased feed biomass availability and efficient feed utilization improves livestock productivity and livelihoods of smallholders in the Highlands of Ethiopia.

Key lessons and challenges

Given the feed resource challenges and future trends, improved forage production has become a necessity, not an option. Farmers realize these challenges and expressed strong demand for new technologies in relation to feeds and forages. Forage intervention has become an entry point to improve both crop and livestock productivity, while maintaining environmental sustainability. The economic benefit for forage intervention has become attractive due to the increasing demand. An important challenge is how to meet the demand for forage seeds and planting materials at an affordable price to ordinary farmers. The livestock value chain, input and output supply chains are additional challenges that need due attention. Capacity building needs to be a core activity to help farmers realize and implement feed resources-related interventions. The forage seed system is also another area of focus while considering scaling out to wider areas and more farmers.

Implications for scaling out

The feed and forage innovations evaluated under this project are scalable at a farm and landscape level across the Ethiopian Highlands by taking into account specific niche requirements. Building the capacity of local development actors to provide practical training and technical support is core to successfully scale the forage options. These technologies are not new, but have not been taken up by farmers or farmers did not have a clear idea of how to manage and utilize them. Therefore, scaling activities need to be preceded by awareness creation and capacitation through cross-site visits, demonstration, and formal and informal training. Targeting farmers who have the capacity to serve as a learning school for other farmers to take up technologies is a feasible horizontal scaling strategy. With the right approach, the right farmer and technology, forage interventions have a huge potential to bring about a positive impact on the livelihood of smallholders and the environment.

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Solar-powered water pumping can boost smallholder income: A business model based on action research from LIVES and Africa RISING sites

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Introduction

The agricultural sector accounts for 0.2% of Ethiopia's energy consumption (Teferra 1986) and 89% of total water withdrawals among which irrigation accounts for 85% (FAO 2016). Solar-powered irrigation as a source of renewable energy and increased efficiency in water application offers the potential to reduce energy and water consumption. Costly diesel-pumping systems pose an economic risk to farmers. The ever-increasing mismatch between demand and supply of energy poses challenges, especially to farmers in remote areas where supply of fuel is a problem and they are forced to look at alternate sources of energy for running irrigation pumps. The high operational cost of diesel pumps may also force farmers to practise deficit irrigation of crops, considerably reducing their yield and income. Therefore, a solar pump can be an alternative to diesel pumps for irrigated crop production. Throughout Ethiopia, the annual distribution of mean daily radiation allows the most efficient use of solar systems (Teferra 1986). Shakti (2014) assessed the benefits of solar water pumping in India and highlighted the crop yield improvements due to timely and adequate water availability for irrigation. In contrast to diesel pumps that have proven to be expensive and environmentally unsustainable, solar pumps provide an environmentally friendly and low-maintenance cost option for pumping irrigation water.

Context

A recent survey by the Chinese firm Hydrochina Corporation (2012) estimated Ethiopia's solar power potential to be around 2 trillion megawatt hours, with the northern part of the country having the greatest potential. Many studies were conducted on the use of solar pumps as a source of energy for water pumping worldwide, but this technology is still in its infant stage in Ethiopia.

In addition, investment in small-scale irrigation has been identified as a key poverty reduction strategy. Given water resources potential, promoting groundwater and surface water use for fragmented land and adoption of household level irrigation technologies is crucial. In its GTP, the government of Ethiopia discussed making use of groundwater by supporting farming households in the adoption and use of private hand-dug wells and suitable water lifting technologies. Since most rural areas are far from electric service in Ethiopia, most hand-dug wells, shallow wells and boreholes are fitted with hand pumps or diesel and petrol-driven generators. Diesel/petrol pumps have many drawbacks such as high running and maintenance costs, unreliable supply of fuel, and poor availability of spare parts. In addition, some of the drawbacks of hand pumps include excess labour, lack of additional services, and disrepair and low-flow rate of the system.

Description of the intervention: approach/technology

The IWMI, through LIVES and Africa RISING projects, piloted eight solar pumps for smallholder irrigation in selected farm households in Oromia and the SNNP Regions. The aim of the pilot was to demonstrate and test whether solar

pumps can provide smallholder farmers with affordable and sustainable irrigation water pumping. A solar pump panel captures sunlight and converts it into electricity which drives the pump (Picture 1).

Picture 1: Piloted solar water pumps.



Besides the pump, we also field tested three water application methods including drip, furrow and overhead (Picture 2).

Picture 2: Demonstrated water application methods—overhead, furrow and drip respectively).



As the amount of water supplied and other costs such as labour, agronomic practices and related costs differ by irrigation method, the pilot design included a comparative analysis. The drip system provides precision in water application leading to decreased water loss from wind and evaporation, hence the long-term advantages may be lower energy, operating costs and water saving.

Results

The overall result shows that investment in a solar pump is profitable, given the minimum land size is available. As solar energy is a clean (zero-carbon) energy, the technology is consistent with the Ethiopian government's CRGE strategy (FDRE 2012). The profitability of the technology depends on crop type and water delivery system, where the drip system was found to be superior to furrow and overhead systems. Our data also show that land size matters, implying that a minimum land size is required for a viable investment in solar pump irrigation. However, the minimum required land size itself depends on different factors, including type of water application system, crop type, discount rate and location. Because access to affordable financing is crucial for smallholder farmers, microfinance institutions can serve as a reliable source of finance rather than the formal banking system.

Key Lessons and challenges

Although high initial investment cost is a potential barrier for smallholder farmers to adopt the technology, cost sharing can be a solution, especially if additional investment is made on drip systems where land size increases to about a half ha. Moreover, partnerships between key actors including rural financial institutions are essential for a positive outcome of investment in solar pumps. While one can argue that commercialization is essential for sustainable market growth, targeted subsidies are needed at the early stage until competitive prices are reached.

In general, solar pumping systems have many advantages including its negligible operating cost. Because there is no fuel or electricity required for the pump, the operating cost is minimal. A well-designed solar pump requires little maintenance beyond cleaning of the panels once a week (Maurya et al. 2015). Solar energy is clean and harmonious with nature. Flexibility is another advantage of solar pumps, because the panels need not be right beside the water source; they can be placed up to 20 meters away from the water source.

However, the technology has some limitations including: 1) the technology that we have piloted is not suitable for large-scale commercial irrigated farms unless the capacity is augmented by adding more panels which in turn increases the investment cost; 2) the water yield of the solar pump changes according to the sunlight. It is highest around noon and least in the early morning and evening. For countries located on the equator, like Ethiopia, which receive about 10 hours of sunlight per day, this is less likely to be a limiting factor.

Implications for scaling out

Based on the analysis, including scope and limitations, of the pilot solar pumping system, we recommend that attention be given to the system of irrigation water distribution and application to the crops. For example, our pilot experiment shows that when a solar pump is supplemented with a drip system, the size of irrigable land is almost doubled as compared to furrow and overhead irrigation and minimizes water loss. Equally important is its effect of reduced labour use per ha.

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AVCD

The AVCD program, funded by USAID and implemented by ILRI, the International Crops Research Institute and the International Potato Center, applies technologies and innovations for selected value chains (livestock, dairy, staple root and drought-tolerant crops) to competitively and sustainably increase productivity, and contribute to FtF goals of inclusive agricultural growth, nutrition and food security in Africa. AVCD works closely with other projects and partners to enhance resilience, agricultural productivity, food security and the overall economic welfare of farmers, producers and marketers throughout the value chain. While the entry point is scaling up application of agricultural technologies and innovations, the program addresses the weakest points of the value chain to benefit all value chain players. The goal of the program is to sustainably reduce poverty and hunger in the FtF zones of influence in Kenya.

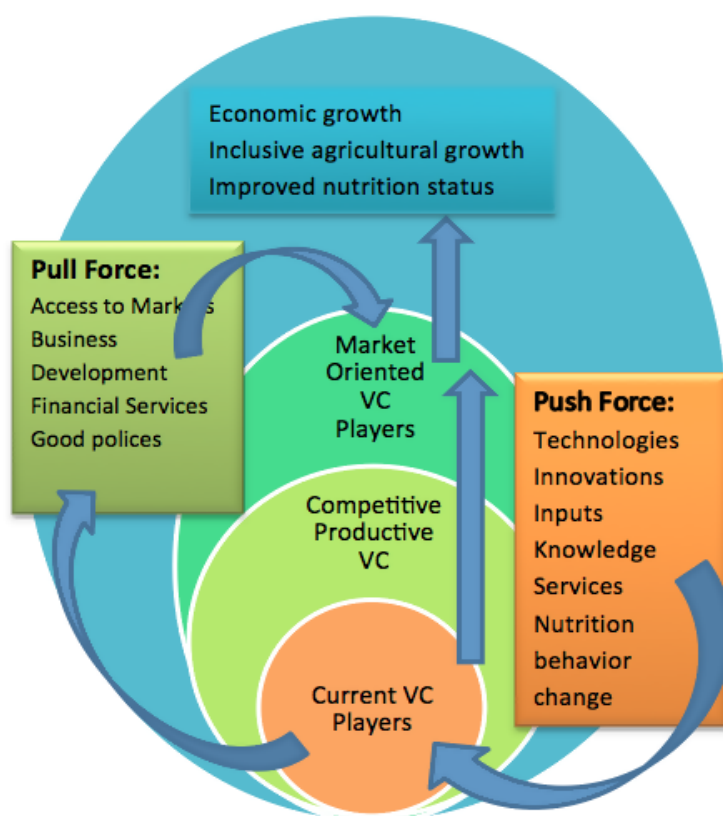
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government and donors are perceived as the key actors, often displacing the private sector, farmers' organizations and other NGOs.

This model has not worked well in Africa and many programs failed to achieve the desired objectives. Experiences elsewhere, especially in Brazil, India and some East Asian countries, have shown that a more holistic and inclusive approach that takes into account the whole value chain from technology development to consumption, with greater emphasis on markets and monetary value added, is more appropriate. It is for these reasons that in the last decade or so, there has been concerted efforts at international and national levels towards a process of whole value chain development and market-oriented research and development programs.

The FtF AVCD program theory of change draws from these lessons in Kenya. Analysis conducted under the program has concluded that a two-prong approach is needed in order to achieve the goals and development objectives of economic growth, inclusive agricultural growth and improved nutrition status for women and children. On one front, the strategies to be applied are to exert the push (supply) effect (Figures 2 and 3). These strategies include improving access to knowledge tools (technologies and innovations), buying down risk (increase resilience), improving nutritional status, and enhancing natural resource management. The second front is to exert a pull (demand) effect on agricultural growth, including improved market linkages, re-aligning business regulatory policies, improving inputs access and strengthening business. Utilization of the whole value chain approach (production to consumption), allows the application of push (supply) and pull (demand) forces in value chain development, eventually resulting in competitive, productive and market-oriented value chain development.

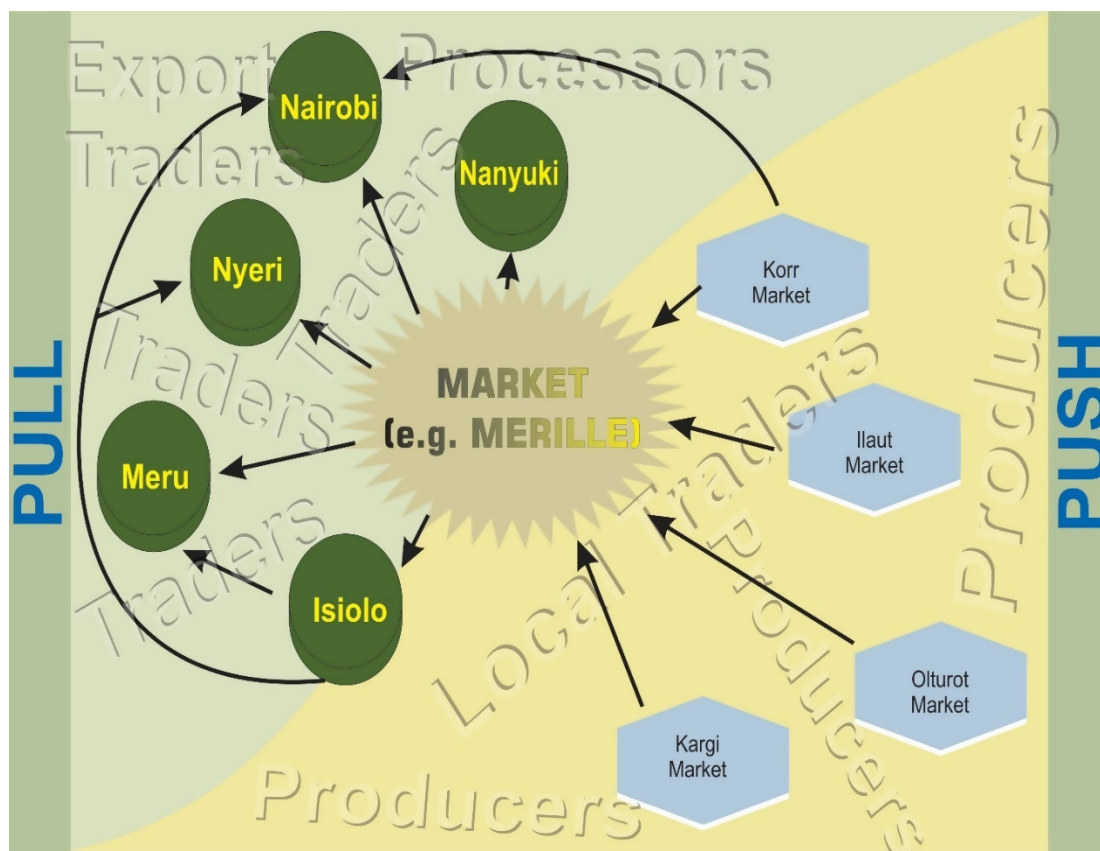
Figure 2: Theory of Change for the FTF-AVCD program.



The Kenyan livestock sector contributes about 8% to GDP, valued at USD96.08 million. Over 70% of Kenya's livestock is found in arid and semi-arid areas in predominantly pastoralism land use systems that are resilient. During the 2008–11 drought, these areas suffered a loss of USD8 billion of livestock, coupled with severe hunger and malnutrition. Some of the challenges plaguing the Kenyan arid and semi-arid lands include low productivity and quality, and lack and/or limited access to marketing information systems. ILRI is tasked with the implementation of the

livestock value chain because it has technologies and global experience in livestock research and development. As part of the overall strategy, the project supports the county government through the Kenya Livestock Marketing Council (KLMC), to exert more efforts on both push and pull forces (Figure 3). On one hand, it supports the producers to service the quality and the volume demanded by the market, while on the other hand, supporting the upstream linkages to various end market actors, including national, regional and export traders and processors as well as sector regulators (Kenya Bureau of Standards, director of veterinary services etc.), aimed at creating an effective demand. To achieve this, the project supports regular coordination forums with producers and marketing groups. For example, the Accelerated Value Chain Development-Livestock Component (AVCD-LC), through KLMC has positioned the respective county governments not only to champion the end market mobilization but also create a supportive environment necessary for a thriving demand-driven livestock trade. The project works to invest in scaling out innovative livestock marketing models, e.g. the Northern Rangelands Trust Livestock-to-Markets model.

Figure 3: The pull and push effects in the livestock value chain.



Results

Case study I: Improving knowledge base for animal disease surveillance in pastoralist systems in Kenya

Among the numerous challenges that pastoralists face in their livestock production systems, animal diseases greatly affect not just their livestock productivity, but also their livelihoods as a whole. While pastoralists may have some knowledge on endemic livestock diseases that they have been exposed to before, in many circumstances their perceptions on the causes of some of the diseases and methods of control are erroneous and detrimental. Huge losses from livestock diseases are incurred due to delayed response as well as misdiagnosis that leads to wrong treatment and control, and misuse of veterinary drugs along with misconceptions about vaccination campaigns.

Picture 1: Livestock keepers trained as disease surveillance champions explain illustrations from a training manual to a livestock owner in Turkana County (photo credit: ILRI).



Given the nomadic nature of pastoralist systems, producers often lack convenient access to animal health service providers. Against this backdrop, ILRI implemented the USAID FtF-AVCD in collaboration with the county governments of Wajir, Garissa, Isiolo, Marsabit and Turkana in the Northern Province of Kenya to equip pastoralists with skills on animal disease surveillance. Under the livestock component of the FtF-AVCD program, ILRI implemented a three-tier training of trainer model to train government veterinarians, community disease reporters and *manyatta*-based disease surveillance champions on the symptoms of prevalent livestock diseases. The objective of this training model is to improve the knowledge base among the value chain actors on the diseases, their symptoms and how the diseases are described at different levels. Using tailored manuals with pictures and illustrations for ease of recognition of these diseases, disease surveillance champions have been trained as trainers, who in turn have trained more than 1,100 livestock keepers (Picture 2) in Turkana County, one of the project counties.

Picture 2: Ms Paulina Natuko (standing) a disease surveillance champion facilitating livestock disease recognition training for livestock producers in Napiekar, Turkana County (photo credit: ILRI).



Case Study 2: Healthy goats, healthy returns: Enhancing small ruminants' productivity for improved pastoralist livelihoods in northern Kenya

Goats are among the small ruminants that play an important role in the pastoralists' households. The goat industry contributes substantially to the Kenyan economy, with a greater population of these reared by pastoralists in the arid and semi-arid lands. However, despite the significance of goat rearing in improving pastoralist livelihoods, numerous challenges hamper these production systems, notably a range of diseases and feeding constraints. One of the major diseases that greatly affect goats and significantly negatively impacts their production is the contagious caprine pleuropneumonia (CCPP), a highly severe and infectious respiratory disease, affecting goats and wildlife. It is widespread and endemic in the pastoral production systems in Kenya.

ILRI through AVCD works to improve the income and nutritional status of households in northeastern Kenya by focusing on improving the value of livestock and productivity with better animal disease surveillance and health. Garissa and Marsabit Counties have been experiencing high incidences of goat mortality as a result of the CCPP disease. At different times in 2016, the county departments of veterinary services in the two counties experienced CCPP outbreaks recorded up to 50% mortality rate of the goats. AVCD teamed up with the respective county governments and other partners (REGAL-IR and local agro-vets Sidai and MEDINA) to promote a public-private partnership model for sustainable animal health service delivery in both counties. In this partnership, the county government provided the vaccines and the campaign team, while AVCD livestock facilitated the private agro-vet operators to participate in the vaccinations by providing veterinary inputs (dewormers, acaricides etc.) at cost at the various vaccination points that included water points among others. County governments had over the years provided these inputs without charge, with devastating consequences to the animal health delivery chain. The increased interaction and linkages between the various actors/stakeholders led to veterinary drugs quality control, improved disease reporting and also embedding of veterinary extension. This approach enables the public sector to leverage on the resources available within the private sector to increase animal health services outreach to otherwise neglected smallholder pastoralists producers.



a). County veterinary officials vaccinating goats against CCPP



b) Sidai veterinary experts dispensing drugs

Picture 3: AVCD LC experience and lessons learned.



c) Sidai, a privately operated agro-vet, carrying out veterinary extension



d) Questions and answers session with Sidai agro-vet personnel

Key lessons and challenges

Regarding Case Study 1, 'Improving knowledge base for animal disease surveillance in pastoralist systems in Kenya', in addition to building the knowledge base, the three-tier train-a-trainer module reinforces the existing surveillance and disease control network involving the county veterinarians, community surveillance champions and the producers and market actors.

Regarding Case Study 2, 'Healthy goats, healthy returns: Enhancing small ruminants' productivity for improved pastoralist livelihoods in northern Kenya', the program provided training for farmers and community disease reporters on common goats and sheep diseases. In addition, private animal health technicians also received training on commonly used drugs, practical training sessions on vaccine administration to goats and sheep, and variation of vaccines and doses administered per species. Specifically, in response to the reports on goat mortality in Garissa County, AVCD livestock organized and facilitated a vaccination campaign in May 2016, targeting two common diseases; CCPP and sheep and goat pox. A total of 18,419 shoats (13,229 goats and 5,190 sheep) were vaccinated against CCPP and sheep and goat pox.

Implications for scaling out

Regarding Case Study 1, 'Improving knowledge base for animal disease surveillance in pastoralist systems in Kenya', this model has facilitated interaction and linkages between community disease reporters, county government and livestock producers for improved disease surveillance and reporting. In addition, the model is building the capacity of livestock producers to demand quality veterinary services.

Regarding Case Study 2, 'Healthy goats, healthy returns: Enhancing small ruminants' productivity for improved pastoralist livelihoods in northern Kenya', through this approach, linkages have been established between the state departments of livestock at the government ministries, the community disease reporters, farmers and private agro-vets and animal health service providers. In Garissa, Sidai agro-vet is working closely with the livestock and veterinary offices to supply vaccines and carry out vaccination.

N2Africa

Active since 2009, N2Africa is a large scale, science-based ‘research-in-development’ project focused on putting nitrogen fixation to work for smallholder farmers growing legume crops in Africa. It is funded by the Bill & Melinda Gates Foundation.

Legumes bring atmospheric nitrogen into crops and soil through a symbiosis with *Rhizobium* bacteria, and they are an important source of protein in a healthy diet. Enhanced productivity of legumes thereby contributes to improvements in soil fertility, household nutrition and income. N2Africa enables African smallholder farmers to reap these benefits through the implementation of effective production technologies including inoculants and fertilizers.

N2Africa links scientific research with capacity building (from farmers to traders, development workers in extension and NGOs), educating master of science and doctoral candidates, women’s empowerment, and access to input-output markets through public-private partnerships. A strong network ensures continuous and independent improvement of technologies and market access.

N2Africa participating countries include Ethiopia, Tanzania, Uganda, DR Congo, Ghana, Kenya, Malawi, Mozambique, Nigeria, Rwanda and Zimbabwe. Focal legume crops are common bean, chickpea, cowpea, faba bean, groundnut and soyabean.

<https://www.n2africa.org/>

Smallholder farmers' legume technology adoption preferences: Evidences from the N2Africa project

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Introduction

There is continued interest in studying and describing farmers' technology adoption behaviour (Feder et al. 1985; Knowler and Bradshaw 2007), but no simple answer has emerged as to the determinants. A long list of explanatory variables requiring different policy interventions have been identified and suggested to explain the adoption behaviour of farmers. Farmers' preferences for the type of intervention rarely appear in the explanatory variables. In this respect, prior identification of farmers' preferences can help to design more acceptable and cost-effective development intervention programs.

Context

Most studies dealing with agricultural technology adoption by farmers in developing countries are largely based on ex-post analysis of intervention programs. Farmers are rarely consulted, a priori, about their specific circumstances, priority problems and their preference for type of intervention (Feder et al. 1981). Adoption or nonadoption of agricultural technology were influenced by a set of independent variables like farmer and household characteristics, and psychological, socio-economic and institutional factors (Seife and Caroline 2011). However, the low rate of adoption for improved and new technologies by farmers might also be influenced by the different attributes that farmers assign in their choice for technology adoption. Their omissions in adoption may bias the results of the factors determining adoption decisions of users (Adesina and Baidu-Forson 1995).

Despite these efforts, there have been no studies that address the adoption of legume technology using a joint attribute preference setting in order to understand how farmers' preference for different types of attributes determines legume technology adoption. This study was, therefore, initiated to examine factors that influence farmers' legume technology adoption preference in Damot Gale and Boricha districts of Wolayita and Sidama/Zones of the Southern Region of Ethiopia.

Description of the intervention: approach/technology

The SNNP is one of the four largest regions in Ethiopia. The main economic activity in the region is agriculture. The study was conducted in Damot Gale and Boricha districts. Both districts were selected based on their legume production potential and the fact that they are target areas of the N2Africa project which is working on putting N fixation to work for smallholder farmers in Africa. SNNP's economy is based on mixed agriculture.

This study employed both qualitative and quantitative methods of data collection. Data were collected from both secondary and primary sources generated through exhaustive literature review around the issue at hand, a case study and structured questionnaire. The study critically evaluated the existing literature on the factors and issues related to farmers' technology adoption.

A two-stage sampling procedure was employed to select chickpea and common bean producing samples of farm households. A combination of purposive and random sampling techniques was employed. In the first stage among

potential chickpea and common bean producing kebeles that are target areas of the N2Africa project, four kebeles were selected purposively from both districts. At the second stage, a random sampling technique was applied to obtain the sample unit based on the number of chickpea and common bean producing households in each kebele. The sample size for this study was determined using Yamane's (1967) formula.

The data were analysed using descriptive statistics such as mean, percentage and standard deviation to characterize the farming system of the study area. The conjoint model was used to assess the preferences of farmers for legume technology, and Ordinary Least Square (OLS) regression was used to analyse the factors that influence farmers' adoption preference of technology.

For this research, four attributes and 10 levels were identified for each crop (chickpea and common bean). The four attributes to be evaluated were selected based on the factor analysis results from sample surveys. The conjoint survey involved farmers rating hypothetical technologies or varieties that were based on combinations of the four attributes and their levels as follows: seed variety (Habru, Arerti, Natoli and local variety for chickpea) (Nasir, Ebado, Awassa dume and Red welayita for common bean), fertilizer (DAP only and DAP and inoculant), fungicides (with fungicide and without fungicide) and payment option (50% pre-payment and 100% full payment).

The estimation for the coefficients was derived through the linear regression model to determine the utility value of each attribute level. The basic conjoint model in this research was represented (Shalini and Msood 2010) as:

m, k_i

$$U(X) = \sum_{i=1}^m \sum_{j=1}^{k_i} \alpha_{ij} x_{ij}$$

$i=1, j=1$

Where,

$U(X)$ = Overall utility (importance) of an attribute,

α_{ij} = part-worth utility of the j th level of the i th attribute,

$i=1, 2, \dots, m, j=1, 2, \dots, k_i$,

$x_{ij} = 1$, if the j th level of the i th attribute is present

$= 0$, otherwise.

For this study, the OLS model used is specified as follows.

$Y_{im} = \beta_0 + \beta_1(\text{Habru seed variety}) + \beta_2(\text{Arerti seed variety}) + \beta_3(\text{Natoli seed variety}) + \beta_4(\text{With Fungicide}) + \beta_5(50\% \text{ pre-payment}) + \beta_6(\text{DAP}) + \beta_7(\text{Age}) + \beta_8(\text{Land size}) + \beta_9(\text{Credit access}) + \beta_{10}(\text{Cooperative union membership}) + \epsilon_{im}$for chickpea producers in Damot Gale district.

$Y_{im} = \beta_0 + \beta_1(\text{Nasir seed variety}) + \beta_2(\text{Awassa dume seed variety}) + \beta_3(\text{Red welayita seed variety}) + \beta_4(\text{With fungicide}) + \beta_5(50\% \text{ pre-payment}) + \beta_6(\text{DAP}) + \beta_7(\text{Age}) + \beta_8(\text{Land size}) + \beta_9(\text{Credit access}) + \beta_{10}(\text{Cooperative union membership}) + \epsilon_{im}$for common bean producers in Damot Gale district.

$Y_{im} = \beta_0 + \beta_1(\text{Nasir seed variety}) + \beta_2(\text{Ebado seed variety}) + \beta_3(\text{Awassa dume seed variety}) + \beta_4(\text{With Fungicide}) + \beta_5(50\% \text{ pre-payment}) + \beta_6(\text{DAP}) + \beta_7(\text{Age}) + \beta_8(\text{Land size}) + \beta_9(\text{Credit access}) + \beta_{10}(\text{Cooperative union membership}) + \epsilon_{im}$for common bean producers in Boricha district.

Where: Y represents the rating value given by respondent on the 5-point Likert scale.

Results

Regarding common bean producers in Damot Gale district, the regression analysis indicated that, out of the four socio-economic variables, age of household and credit access have significant relationships with common bean legume technology package adoption preference. With respect to age, the regression result shows that age has a positive

influence on adoption preference. Credit access is negatively and significantly related to adoption preference of legume technology. This result is in agreement with the findings of Onyenweaku et al. (2010), which opined that diversion of agricultural credit to nonfarm uses is the reason for the negative sign of credit. In Boricha district, all of the four socio-economic variables were found insignificant to technology adoption preference.

In the case of chickpea producers in Damot Gale district, among the four socio-economic variables, age, credit access and cooperative union membership positively and significantly affects adoption preference of legume technology. However, land holding in ha negatively affects legume technology package adoption preference, in line with the findings of Etoundi and Dia (2008) which pointed out that increasing the area diminishes the probability of adopting the improved maize variety. The reason was that a large area sown with maize requires much manpower and resources. This may mean that farmers without cash and no access to credit will find it very difficult to attain and adopt new technologies.

While measuring utility values among seed attribute levels of Habru, Nasir and Ebado varieties, and from fertilizer DAP and payment option, 50% pre-payment has the highest utility values by chickpea and common bean producers in Damot Gale and Boricha districts. Regarding fungicides, with fungicide attribute level has the highest utility in Damot Gale for both crops whereas in Boricha district it is the least preferred. The graph below presents the utility estimates of each attribute level of chickpea and common bean legume technology packages in both districts.

Figure 1: Utility estimates of chickpea attribute levels Figure 2: Utility estimates of common bean attribute levels.

Key lessons and challenges

The study identified that among common bean and chickpea producing farmers in Damot Gale district the relative importance among legume technology packages, chickpea producers' seed (60.14) is the most important factor, fungicide (15.74) is the second important factor, payment (14.65) is the third and fertilizer (9.47) is the least important factor. Similarly, for common bean producers in Damot Gale district, seed (60.53) is the most important factor, fungicide (16.67) is the second important factor, payment (13.02) is the third and fertilizer (9.78) is the least important factor. Regarding relative importance of attributes for common bean producers in both districts, seed (38.16) has the higher relative importance, payment (33.35) is the second most important attribute, fertilizer (13.44) is the third and fungicide (15.05) is the least important attribute for both districts.

While measuring profile (technology package) rankings of common bean producers in Damot Gale district, a technology package which is composed of Nasir variety, 50% pre-payment and with fungicide received the highest preference. For common bean producers in Boricha district, Ebado seed variety, DAP, 50% pre-payment and with fungicide is the most preferred package. Regarding chickpea producers of Damot Gale district; Habru seed variety, DAP, 50% pre-payment and with fungicide is the most preferred package.

Based on this study, the following recommendations are made. First, from the results of this study, we conclude that the subjective preferences of farmers need to be addressed while making any future technology adoption interventions among them. The cultural background of farmers, ecological conditions, available technologies and manpower, and many other factors constitute a context within which farmers decide to adopt an innovation, so differences need to be noted. For better adoption, there should be market segmentation based on farmers' preference for different attributes of legume technology (i.e. seed multipliers and cooperative unions should focus on supplying different types of seed based on farmers subjective preference and chemical input provision like fungicide based on the environmental problems).

Second, training and farm demonstrations are needed in order to distinguish the benefits of applying only DAP versus DAP and inoculants combined. From the conjoint profiles, the most preferred profiles are composed of DAP whereas DAP and inoculants combined has a negative relation to preference. However, DAP and inoculants are more productive than DAP alone. To promote adoption of inoculants, there is a need for more demonstrations so that farmers can observe the difference in productivity.

Finally, partnership creation between farmers and financial institutions for credit access as well as partnerships between farmers and marketers (farmer unions) will benefit farmers (including better prices and ability to repay loans).

Implications for scaling out

Further study is needed to distinguish between credit-constrained and credit-unconstrained farmers in order to explain the reason for the negative relationship of credit to legume technology package adoption preference.

There is also a need for a longitudinal study to confirm consistency of the factors across multiple years. Such longitudinal data could give conclusive findings for generalization of broader future technology intervention. In general, the results might indicate that technology preference by smallholder farmers needs to be considered in terms of packages where farmers might evaluate several attributes jointly for their adoption decision.

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Inoculation and phosphorus fertilizer increases food and feed production in grain legumes: farmers' perception and treatment effects on yield and nutritive quality of residue biomass in the Ethiopia highlands

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Introduction

Grain legumes are the second largest crop produced in Ethiopia (CSA 2015); cereals are the first. Grain legumes are largely produced in a smallholder crop-livestock production system which is a predominant agricultural activity in the Ethiopian Highlands. In this farming system, both crop and livestock production are vital for the livelihood of the farming households. In most cases, the livestock and crop subsystems have a strong interdependence and are complementary (Getachew et al. 1993). Livestock provide inputs (traction and manure) for crop production whereas crop residues are used as livestock feed (Powell et al. 2004). The increasing dependence of smallholder mixed crop-livestock farmers on crop residues as a source of livestock feed calls for research and development efforts to improve crop residue yield and quality without sacrificing grain yield and quality.

Context

This study was conducted to evaluate effects of P fertilizer and *Rhizobium* inoculation on DM yield and nutritive value of grain legume haulm and to assess legume haulm utilization practices of the farmers as well as their perception of the impact of *Rhizobium* inoculation and P fertilizer on haulm biomass yield and quality.

Description of the intervention: approach/technology

This study was conducted in selected districts that are sites in the ILRI-N2Africa project for pilot implementation in Ethiopia during the main cropping season of 2015–16. The study was superimposed on demonstration plots established on selected farmers' plots for best-bet grains and legumes technologies demonstration. Four fertilizer treatments vs. control (-P-I), P fertilizer only (+P-I), *Rhizobium* inoculation only (-P+I) and P fertilizer and *Rhizobium* inoculation (+P+I) were applied to four grain legumes (faba bean, chickpea, haricot bean and soyabean), which were established on 10 x 10 m plots per treatment. Grain and haulm yield data were collected and nutritional quality of the grain and haulm were determined. In addition, 90 farmers engaged in the N2Africa project in Ada'a, Sinana and Damot-Gale districts were interviewed using semi-structured questionnaires to obtain information on use of legume haulms and perception of farmers on the effects of the treatments on haulm yield and quality. Survey data were analysed using Statistical Package for the Social Sciences (SPSS Ver. 16), whereas yield and nutritive value data were analysed using analysis of variance (ANOVA) using general linear model procedure of SAS 9.1 in randomized complete block design considering farms as block factor.

Results

Grain legumes haulm use practices in the study area

Haulm use practices of the households are presented in Table I. The haulm is predominantly (76.7%) used as livestock feed followed by biofuel (11.4%), mulching and biofertilizer (8.8%), and means of income (3.1%). Ninety per cent of the

respondents reported an increasing trend of using grain legume haulms as livestock feed, which is consistent with the report of Alkhtib et al. (2012). Shortage of feed and lack of other options, increased production of legume haulms and improved awareness on the feeding value of haulms were mentioned as major contributors for increasing interest in legume haulm use as animal feed.

Table 1: Purpose and usage trend of grain legume haulms as livestock feed in the mixed crop-livestock farming system of Ethiopia

| Variables | Measures | Household responses (%) |
|-----------------------------|------------------------|-------------------------|
| Uses of haulms | Feed source | 76.7 |
| | Biofuel | 11.4 |
| | Mulching/biofertilizer | 8.8 |
| | Income source | 3.1 |
| Trends of haulm use as feed | Increasing | 90.0 |
| | No change | 5.6 |
| | Don't know | 4.4 |

Perceptions of respondents on effects of treatments on haulm yield and quality

The perception of the respondents on the impacts of *Rhizobium* inoculation and P fertilizer on biomass yield and quality of the haulm is given in Table 2. Most (62.2%) of the households perceived that *Rhizobium* inoculation and P fertilizer affect haulm biomass yield, whereas only 32.2% of the respondents perceived that the treatments affect nutritional value of the haulm. All respondents indicated that application of these inputs increased haulm yield through improvement of vegetative growth of the crop, whereas 62.1% of the respondents reported positive effects of the treatment on haulm nutritional quality. Haulms with a high proportion of leaf (higher leaf to stem ratio) have better quality than stem- rich residues. Farmers' perceptions on the impacts of fertilizer on crop yields are closely associated with estimated returns to fertilizer applications (Marenja et al. 2008), which are mainly driven by observed yields responses.

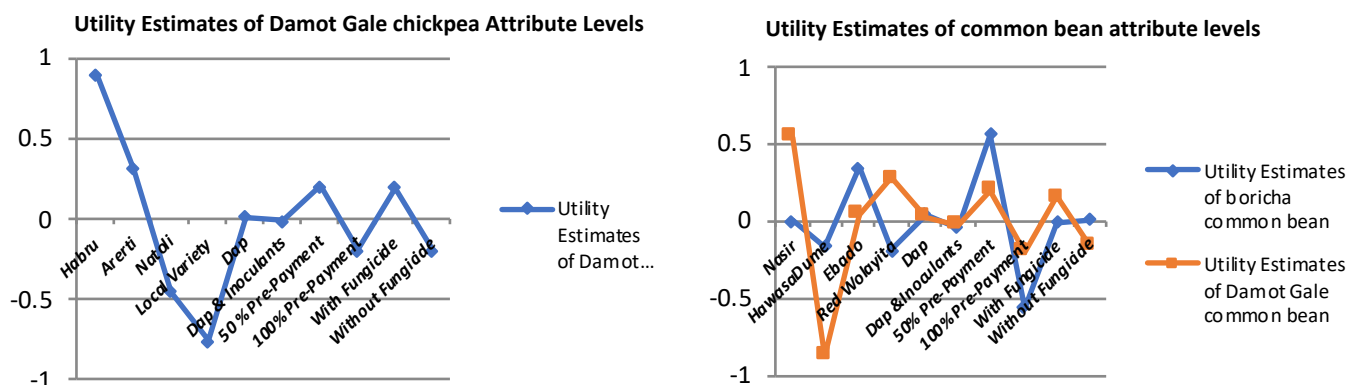
Table 2: Household perception of inoculation impacts and P application on haulm traits

| Variables | Measures | Haulm yield (%) | Haulm quality (%) |
|--|------------|-----------------|-------------------|
| Do you think inoculants and P* fertilizer application affect...? | Yes | 62.2 | 32.2 |
| | No | 13.3 | 21.1 |
| | Don't know | 24.5 | 46.7 |
| | Total | 100 | 100 |
| What impact is expected? | Improved | 100 | 62.1 |
| | Decreased | - | 37.9 |
| | Total | 100 | 100 |

Effects of the treatments on grain and haulm DM yield

Grain and haulm yield responses of faba bean, chickpea, haricot bean and soyabean to *Rhizobium* inoculation and/or P fertilizer is shown in Figures 2 and 3. In all crops, the maximum grain yield was recorded in treatment +P+I, though in faba bean, the yield obtained from sole P fertilized treatment (+P-I) was almost similar to that of +P+I. Haulm yield was significantly ($P < 0.05$) improved due to the treatments in all crops except chickpea. The highest haulm DM yield was recorded in treatment +P+I for faba bean and haricot bean, while both inoculated treatments (-P+I and +P+I) resulted in significant increment of haulm DM yield in soyabean.

Figure 1: Grain yield responses of the legumes to *Rhizobium* inoculation and/or P fertilizer.



The increased grain and biomass yield could be associated with increased plant available nutrients especially N and P. Ibsa (2013) reported increased chickpea grain yield due to inoculation and P fertilizer, while significant improvement of chickpea grain yield was reported with the inoculation of chickpea seed with dual microbial fertilizers (Tagore et al. 2014). Similar to grain yield, evidence from the literature (Khaim et al. 2013; Tagoe et al. 2014; Yagoub et al. 2012) is available on the positive effects of various nutrient source fertilizers on grain legumes haulm yield.

Figure 2: Haulm yield responses of faba bean, chickpea, haricot bean and soyabean to *Rhizobium* inoculation and/or P fertilizer.

Effects of the treatments on nutritional value of grain legumes haulm

The nutritional value of grain legume haulms is presented in Table 3. The crude protein (CP) and metabolized energy (ME) contents and in vitro organic matter digestibility (IVOMD) of faba bean haulm harvested from input supplied treatments (-P+I, +P-I, and +P+I) were higher ($P < 0.05$) than the control (-P-I), whereas the reverse was true for neutral detergent fiber (NDF) content. In chickpea haulm, the highest CP and ME contents and IVOMD values were recorded in +P+I. The highest CP and ME contents and IVOMD were obtained in haricot bean haulm from +P+I treatment, whereas the same treatment had low NDF content. Higher CP content of soyabean haulm was recorded in inoculated treatments (+P+I, -P+I), whereas the lowest NDF value was found from treatment +P+I. The IVOMD of soyabean haulm was highest in the +P+I treatment. Similar to the current results, positive and highly significant effect of P level and biofertilizer on haulm N (CP) content of faba bean was reported by Habbasha et al. (2007). Ibsa (2013) also showed significant improvement of haulm CP content due to *Rhizobium* inoculation. The increased IVOMD of the haulms could be due to higher CP and ME contents with concomitant reduction in fibre content.

Table 3: Effects of *Rhizobium* inoculation and P fertilizer on haulm nutritional value of faba bean, chickpea, haricot bean and soyabean in Ethiopia

| Crop species | Parameters | Treatment | | | | Level of sig. |
|--------------|---------------|-----------|--------|-------|-------|---------------|
| | | +P+I | -P+I | +P-I | -P-I | |
| Faba bean | CP (%DM) | 6.52a | 6.45a | 6.38a | 5.25b | * |
| | NDF (%DM) | 64.9b | 64.9b | 64.8b | 70.5a | * |
| | IVOMD (%DM) | 47.0a | 46.4a | 46.7a | 43.0b | * |
| | ME (MJ/Kg DM) | 6.85a | 6.77a | 6.81a | 6.29b | * |
| Chickpea | CP (%DM) | 4.32a | 3.66b | 3.60b | 3.31c | *** |
| | NDF (%DM) | 62.1 | 63.0 | 63.5 | 63.2 | Not sig. |
| | IVOMD (%DM) | 47.7a | 46.5ab | 45.8b | 45.9b | ** |
| | ME (MJ/Kg DM) | 7.36a | 7.14b | 7.07b | 7.06b | ** |

| Crop species | Parameters | Treatment | | | | Level of sig. |
|--------------|---------------|-----------|--------|--------|-------|---------------|
| | | +P+I | -P+I | +P-I | -P-I | |
| Haricot bean | CP (%DM) | 7.50a | 6.85ab | 6.72b | 5.94c | ** |
| | NDF (%DM) | 67.8b | 69.0ab | 69.9a | 69.8a | * |
| | IVOMD (%DM) | 57.8a | 56.8ab | 55.8b | 55.7b | * |
| | ME (MJ/Kg DM) | 8.72a | 8.65ab | 8.58b | 8.58b | * |
| Soyabean | CP (%DM) | 6.74a | 6.08a | 5.30b | 4.67b | *** |
| | NDF (%DM) | 74.1b | 75.3ab | 75.5ab | 76.4a | * |
| | IVOMD (%DM) | 50.6a | 50.2ab | 49.4b | 49.6b | ** |
| | ME (MJ/Kg DM) | 8.82 | 8.79 | 8.76 | 8.74 | Not sig. |

Key lessons and challenges

Rhizobium inoculation and P fertilizer increased grain and haulm yields in all studied crops except for DM yield of chickpea haulm. The treatments also improved the CP and ME contents while reducing the fibre content of the haulm which resulted in improved digestibility (IVOMD).

Implications for scaling out

Rhizobium inoculation and P fertilizer can be used to enhance whole plant use of grain legumes in smallholder mixed crop-livestock production systems.

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Conclusion

Action research projects in the agricultural sector implement research protocols on development interventions along commodity value chains and systems to assess their feasibility, effectiveness and outcomes. The design, implementation and results-based monitoring and evaluation of these projects and programs involve all stakeholders along the value chain, from farmers to financial institutions, and include actors from the public to private sector. An important component of action research projects is training the next generation of scientists and policymakers, and encouraging cross-disciplinary collaboration and synergy to tackle developmental issues and obstacles. Action research requires continuous monitoring and evaluation with the goal of attaining long-term desired positive outcomes that are sustainable after the life of the project or program. This requires flexibility in terms of project/program revision based on lessons learned and stakeholder input. Expansion of successful programs and technologies, i.e. scaling out and up, will effect systemic change to the agricultural sector with the ultimate goal of supporting a vibrant, responsive, sustainable agricultural system with manageable environmental stress that provides adequate nutrition and income to all people.

LIVES, Africa RISING, AVCD, and N2Africa are collaborative projects that rely upon strong partnerships to achieve their objectives. Review of program successes and challenges ensures that future pilot projects and action research are responsive to realities on the ground.

Annex

Workshop and exhibition program

| Thursday 8 December 2016 | | | |
|--------------------------|---|--|---------------------|
| Time | Activity | Responsible Person | Chair/Facilitator |
| 8:30-9:00 | Registration | Organizers | |
| 09:00-9:05 | Workshop objectives and expectations | Siboniso M. | Berhanu Gebremedhin |
| 09:05-09:10 | Welcome remark | MoLF, H.E. Dr. Gebregziabher Gebreyohannes | |
| 09:10-09:20 | Opening speech | MoANR, H.E. Dr. Eyasu Abreha | |
| 09:20-10:00 | Panel on LIVES, N2Africa, Africa RISING, FtF Mali and AVCD Kenya action research approaches | Peter T., Azage T., Endalkachew W., Abdou F., and George W. | |
| 10:00-11:00 | <i>Presentations:</i> Feed development LIVES feed value chain development interventions: approaches and scalable interventions Feed innovations for improved livestock productivity in the Ethiopian Highlands: Africa RISING experiences Inoculation and P fertilizer improves seed and feed production in grain legumes in Ethiopian Highlands: farmers' perceptions, and treatment effects on yield and nutritive quality of residue biomass Enhancing Productivity and market access: Initial lessons learnt from Mali Livestock Technology Scaling Program | Presenters LIVES Africa RISING N2Africa FtF Mali | Peter Thorne |
| 11:00-11:15 | Coffee break/group photo | Participants | |
| 11:15-11:30 | Discussion | Organizers | |
| 11:30-12:30 | <i>Presentations:</i> Livestock value chain LIVES small ruminant value chain development interventions: Approaches and scalable interventions LIVES poultry value chain development interventions: Approaches and scalable interventions LIVES dairy value chain development interventions: Approaches and scalable interventions A model for enhancing animal health service delivery through public-private partnerships under pastoral systems: preliminary observations from AVCD project in northern Kenya | Presenters LIVES AVCD Kenya | Azage Tegegne |
| 12:30-1:30 | Lunch | Organizers | |
| 1:30-3:00 | Exhibition/poster and coffee break | LIVES, N2Africa and Africa RISING | |

| | | | |
|-----------|--|--|----------------|
| 3:00-4:00 | <p><i>Presentations:</i> Crop value chain</p> <p>Crop varieties research and implications on closing yield gaps and diversifying incomes - Africa RISING experiences</p> <p>Evidence based assessment of scalability of agricultural technologies: The case of improved food legumes and small ruminant market sheds - Africa RISING experiences</p> <p>The PPP (Private-Public-Partnership)-an ILRI-N2Africa initiative for promoting legume technology dissemination and value chains to benefit smallholders</p> <p>Smallholder farmers' legume technology adoption preferences and contributions to farmers' performance: Evidence from N2Africa project</p> | <p>Presenters</p> <p>Africa RISING</p> <p>N2Africa</p> | Kindu Mekonnen |
| 4:00-4:30 | Discussion | Participants | |
| 4:30-5:30 | <p>'Coffee shop' presentations</p> <p>Mainstreaming and promoting gender equity in market oriented agricultural development: The LIVES experiences</p> <p>Farmer-based high value crops planting materials production and supply can enhance farm income, create job and support adoption: Examples from LIVES</p> <p>Capacity building approaches and innovations for market oriented agricultural development: Experiences of the LIVES Project</p> <p>IPs: Contributions in the sustainable intensification R4D processes - Africa RISING experiences</p> <p>Scaling of improved forage varieties at selected ILRI-SIMLESA project locations in Ethiopia</p> | <p>Presenters</p> <p>LIVES</p> <p>Africa RISING</p> | Dirk Hoekstra |
| 6:00-7:30 | Reception | Organizers | |

| Friday 9 December | | | |
|-------------------|--|---|-------------------------|
| Time | Activity | Responsible Person | Chair/Facilitator |
| 08:30-9:00 | Recap of the previous day | Facilitator | |
| 9:00-10:00 | <p>Presentations: Soil and water management</p> <p>Feeding hungry and thirsty soils increases yield and protects the environment: Some results of WFD experiment in LIVES</p> <p>Service Provision of Irrigation Water: New ways to step into affordable small scale irrigated agriculture</p> <p>Solar powered water pumping can boost smallholder income sustainability: A business model based on action research from LIVES and Africa RISING sites</p> | <p>Presenters</p> <p>LIVES</p> <p>Africa RISING/LIVES</p> | Tilahun Amede |
| 10:00-10:30 | <i>Discussion</i> | Participants | |
| 10:30-11:00 | <i>Tea break</i> | Organizers | |
| 11:00-12:00 | <p>Presentations: Soil and water management continues</p> <p>Capacitating frontline water lifting technology maintenance service provider reduces risks of crop failure and increases farmers confidence in adopting irrigation: LIVES experiences</p> <p>Decision support tools for farm-level fertilizer recommendation in Ethiopia - Africa RISING experiences</p> <p>Landscape management: Africa RISING R4D experiences in the Ethiopian Highlands</p> | <p>Presenters</p> <p>LIVES</p> <p>Africa RISING</p> | Endalkachew Woldemeskel |
| 12:00-12:30 | Discussion | Participants | |
| 12:30-1:30 | Lunch | Organizers | |
| 1:30-3:30 | <p>'Coffee shop' presentations</p> <p>Knowledge management and promotion for market oriented agricultural development: Experiences of the LIVES Project</p> <p>Agribusiness approaches and methods to promote integration of farmers with markets: LIVES experiences</p> <p>Making the best out of Results-based Monitoring and Evaluation to support project management: LIVES experiences</p> <p>Innovation at LIVES has created job and improved input supply services to smallholder farmers: An example from hybrid tomato planting media development</p> <p>Use of Grain Legumes Residues as Livestock Feed in the Smallholder Mixed Crop-Livestock Systems in Ethiopia: Opportunities to Improve Feed</p> | <p>Presenters</p> <p>LIVES</p> <p>N2Africa</p> | Amare Haileselassie |

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| 3:30-4:00 | Tea break | | |
| 4:00-5:00 | Policy/decision makers reflections/take away messages from the scalable approaches and technologies | MoLF MoANR Regions | Azage Tegegne |
| 5:00-5:20 | Final remarks and the way forward | Siboniso M. | |
| 5:20-5:30 | Closing | H.E. Dr. Gebregziabher Gebreyohannes | |

