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Scaling-up Pulse Innovations for Food and Nutrition Security in Southern Ethiopia (SPIFoNS)

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By

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1. Executive Summary

Pulse crops occupy about 14% of the cropland in Ethiopia and are the second most important component in the national diet after cereals. They complement cereal crops in the diet, as a source of protein and micronutrients. In Ethiopia, many improved agricultural and nutritional practices either remain on a small-scale or have been shelved because of a lack of institutional linkage and coordination, poor communication and dissemination strategies, and lack of capacity and experience. The 'Scaling-up Pulse Innovations for Food and Nutrition Security (SPIFoNS) in southern Ethiopia' project envisages wider-scale impact on the food and nutrition security status of smallholder farmers through scaling up of pulse innovations, reaching 70,000 farm households.

Expanding production of selected common bean and chickpea varieties using improved packages of practices covered fifteen districts (woredas) during the project life time (March 2015-March 2018). A total of 51,068 farmers have been engaged in common bean and chickpea seed and grain production. Of these, 3,324 farmers were organized into 665 seed producing clusters. Out of the total number of farm households participating in seed and grain production of chickpea and common bean technologies, 42% (21,397) were female farmers. Nine seed producing Primary Cooperatives (3 women only coops) were established by organizing clustered farmers. Additionally, Participatory Variety selection (PVS) was conducted in nine project districts and the best site-specific adapted and high yielding varieties of chickpea and common bean were identified, The average productivity of chickpea increased from 2.0 to 2.5 t ha^{-1} while that of common bean increased from 1.2 to 1.5 t ha^{-1} through using high yielding varieties together with site-specific improved agronomic and soil management practices.

The project used different approaches to encourage household awareness and improved income, Birr 18,000 and 5,880 per ha by producing improved varieties of chickpea and haricot bean respectively, especially for rural households. These included, promoting pulse-based foods through nutrition education, using the local government extension system – health extension workers (HEW),health development army (HAD) and 1 to 5 Networks), awareness creation and product promotions led by Farm Radio International (FRI); fine-tuning and promoting pulse-based complementary food processing methods and recipes; chickpea production by extruded snacks and flours by partnering with the private enterprise, Guts Agroindustry, Hawassa. To date 23,059 female farm households have benefited through nutrition education, cooking demonstrations and skill training programs for mothers organized in 1-5 networks (group of 5 women farmers formed as structure for transfer of information). In addition, Peer-led nutrition education intervention on promoting locally available pulses among school-aged children was incorporated into the nutrition intervention strategy for reducing child malnutrition among school children in poor communities. This study was aimed at assessing the effects of peer-led pulse nutrition education on knowledge, attitude, practice of pulse consumption and nutritional status based on 202 school children (101 for intervention and 101 for control groups). Pre-test, post-test and anthropometric measurements done at baseline and end of intervention showed that the mean Diet Diversity Score (DDS) was significantly ($P<0.001$) improved from 2.78 (0.96) to 3.60 (1.10) after six months of intervention in the intervention group. The independent two sample t-test showed significant increase ($p<0.001$) in knowledge, attitude and practice mean scores of school age children about pulse preparation and consumption. Post-intervention, there were significant ($p=0.01$) improvements in intervention over control schools only in BAZ mean score of the children which was reflected in significantly ($P<0.001$) decreased prevalence of thinness. The study concluded that peer led education strategy provides an opportunity to reduce malnutrition and its impacts if properly designed, including the use of behavioral change mode.

In order to bring wider impact in the adoption and scaling up of the innovations and best bet practices, the gender component was superimposed in both agriculture and nutrition components through creating awareness on the crosscut issues of gender mainstreaming. The gender program has been working to integrate gender equality in the effort being made towards sustainable development of agricultural production and nutrition security for rural households. To this end, the program has reached 8,000 community members during the project period. It also empowered women in organizing themselves to play active roles in the agricultural production and utilization of pulses. As part of this women empowerment activity, the gender component of the project facilitated and supported the establishment of three women farmer's primary cooperatives in Misrak Badwacho district in the period between April and October 2017. Two business cases have been piloted, with the lessons learned and resources for future scaling-up activities. Both (micro-franchise and school feeding) are aimed at creating employment for women, while improving household nutritional status by popularizing industrial processed pulses. To-date more than 50,000 BIRR of pulse-food products has been sold by women going door-to-door sales.

2. Research Problem

Food and nutrition insecurity is a major public health problem for the Ethiopian population and there is a need for increased production of high quality pulse crops through the use of best bet varieties and improved crop management practices. Together with processing and preparation of nutritious pulse-based products, these practices can significantly reduce the under-nutrition of Ethiopian children and the community at large. Micronutrient deficiencies, mainly zinc and iron in under-five children, are common in the region and feeding practices remain sub-optimal. Consequently, protein-calorie malnutrition and micronutrient deficiency are prevalent in rural Ethiopia.

Pulse crops occupy about 14% of the cropland in Ethiopia and are the second most important component in the national diet after cereals. They complement cereal crops in the diet, as a source of protein and micronutrients. Agronomically, pulse crops serve as a rotation crop with cereals, reducing soil pathogens and supplying the nitrogen demand of the succeeding cereal crops and to the soil. Despite the critical role they play in Ethiopian agriculture, actual smallholder farm pulse yields are far below their potential. In addition to weather fluctuations and prevalence of disease and insect pests, the possible reasons for the low yields are: growing local and/or low yielding varieties due to inaccessibility, or lack of knowledge of improved varieties by farmers; low fertility status of the soils; application of low inputs and/or growing without any input; and poor management of the fields.

In Ethiopia, many improved agricultural practices either remain on a small-scale or shelved due to lack of institutional linkage and coordination, poor communication and dissemination strategies, and lack of capacity and experience. However, transformation of subsistence agriculture into a more dynamic and market-oriented agriculture requires not only new research findings, but also improving adoption capacity of stakeholders and presenting the innovations in a client-preferred and innovative manner. Scaling-up of improved agricultural practices, can be a valuable and cost-effective strategy to capitalize on past efforts and investments (CIFSRF, 2014). Although many ideas and impactful innovations are effective at pilot or small-scale level, scaling up these practices to a greater number of beneficiaries-and to wider geographical areas brings different challenges and opportunities. Initiatives designed to stimulate wider scale change not only target farming households and their communities but also government policy, operational modalities, and institutional set-up and structures.

Healthy well-nourished households are an outcome of successful social and economic advancement and an essential prerequisite of a people centered development process. Sustainable agriculture is of critical importance to delivering healthy, diversified nutritious diets, along with employment income. This project offered an opportunity to address micronutrient deficiencies critical to achieving Sustainable Development Goals (SDGs). It investigated those factors that could influence adoption of improved pulse varieties for longer term sustainability. Male and females were the center of the efforts to ensure improved consumption of quality pulse-based foods and income/livelihood opportunities.

3 Progress towards project milestones

Table 1.Progress towards milestones (Milestones 1.1-1.13)

#	Milestones	Status C* Completed IP* In progress		Evidence/Indicator	Comment
		C*	IP*		
1.1	Personnel identified and/or recruited, project implementation and evaluation teams formed	X		Project manager at UofS and Coordinator at HU were recruited; Administrative assistant, and 2 Research Assistants, one each for Agriculture and Nutrition components, were recruited at HU; Project implementation team includes research organization, extension, NGOs, and other government and private partners	Recruitment of communication expert at HU was cancelled, and agreement reached to employ consultant whenever necessary.
1.2	Post Docs, PhD & MSc students recruited, and proposals developed	X		2- PhD, 18 MSc [Nutrition (3), (recruited from staff of HU's School of Nutrition, Food Science and Technology), Food Science/postharvest (1), Agriculture (6), Agribusiness and value chain (6) Gender & Family studies (2)] recruited from partner institutions.	3 MSc students discontinued for various reasons; 10 MSc students defended their thesis (the remaining will defend in June 2018. Summarized thesis works are attached (Scientific writing attachment)
1.3	Selection of the project sites	X		Selection of farmers for seed and grain production of chickpea & common bean was conducted at the beginning of each cropping seasons with the help of Regional Bureau of Agriculture and Natural Resources (BoANR).	40% female participation was achieved by including all female-headed households (HH) and females in male-headed HH at each site.
1.4	Stakeholder mapping, strengthening and re-organizing	X		Stakeholders identified, and multi-institutional platforms developed; The roles and responsibilities of every stakeholder defined.	

1.5	Inception workshop and discussion & fine-tuning of milestones	X		Inception workshop held on 7-9, July 2015 at Hawassa, Ethiopia; Milestones discussed & fine-tuned; Full report developed and circulated.	125 participants including State Ministers of Agriculture and Education, Director of MCH, Public and private Stakeholders, NGOs and partners.
1.6	Development of key project implementation strategies	X		Impact pathway, project M/E results framework, communication and policy engagement strategy, scaling up strategy, and gender strategy were developed.	Project partners thoroughly discussed and agreed; 3 Policy Briefs developed and shared; Policy makers field visits conducted in 2016 and 2017.
1.7	Ethics approval obtained	X		Ethics-approvals for PhD/ MSc researches on nutrition were obtained both at HU & UofS	
1.8	Memoranda of Understanding (MoU)	X		Memoranda of Understanding signed with Third Party organizations, and letters of-agreement for participation by other collaborating organizations/scaling up actors were obtained.	HU signed MoU with Bureaus Agriculture, Health, Research Institutes; UofS signed with ICRISAT, Shayashone PLC, FRI, and private partners.
1.9	Meeting of the Scientific and Impact Advisory Board and Project Steering Committee (PSC)	X		Meetings conducted: i. Rome, November 2015; ii. Hawassa, December 2016 iii. Saskatoon, October 14-15, 2016 & May 26, 2017 The PSC met six times: August 2015 in Butajira; 12-14 May 2016, Haile Resort, Hawassa; and 17 December 2016 in Butajira; 08 April and 26 August 2017 @ Haile Resort in Ziway; 30 December 2017 in Butajira; 03 February 2018 in Adama	Exit strategy developed; The PSC shared responsibilities and signed MoU to carry the best results of the project forward

Objective 1					
1.10	Best performing haricot bean varieties distributed	X		20,097 farm households reached with improved varieties of common bean in 15 project districts, exceeding the target to reach 20,000 farm HHs.	Hawassa Dume bean variety, and Habru, Arerti, Teketay and Dalota chickpea varieties reached 51,068 HH (20,097 Bean and 30,971 chickpea)
1.11	Best performing chickpea varieties distributed	X		30,971 farm households benefited in 14 project districts, exceeding the target to reach 30,000 farm HHs.	
1.12	Sustainable local community common bean & chickpea seed system established; 6 Unions and 60 Primary Cooperatives consisting of 3,000 seed producers established.		X	Nine Primary Cooperatives established; Agreement reached with BoANR and the Regional Coop Agency to establish, at least one in each district i.e., a total of 15. The initially planned 60 primary coops could not be achieved due to the requirements in terms of number of farmers and other criteria to form a primary Cooperative. 3,324 farmers engaged in production of chickpea and haricot bean seeds.	Establishment of Unions was not feasible; Regional Bureau of Women and Children Affairs (BoWCA) is on the process of establishing one women only Service Union; The regional BoANR took the responsibility to establish the Coops as agreed on Exit Strategy.
1.13	Location specific varietal and best management trials	X		Site-specific high yielding common bean and chickpea varieties together their improved management practices identified and implemented in nine districts.	Site-specific best agronomic and soil management practices for both crops were implemented (Annex II).

Objective 2

#	Milestone	Status		Evidence/Indicator	Comment
		C*	IP*		
2.1	Innovation Platform for networking policy influences and facilitating scaling up created at regional level	x		Regional Pulse Innovation Platform established (December 2015), and linked to the national platforms (Chickpea and Common Bean).	The platform met twice in Hawassa and Addis.
2.2	Identifying and validating channels, tools and methods for effective scaling up pulse-based interventions	x		Channels identified; Tools developed by ICRISAT, FRI, Shayashone PLC	

Objective 3

#	Milestone	Status		Evidence/Indicator	Comment
		C*	IP*		
3.1	Methods and study design for nutrition program intervention	X		6-studies completed utilizing various approaches, described in Objective 3- Research ➢ Utilization of the governments HEW and 1-5 network ➢ Peer-led nutrition education intervention ➢ Food processing quality and storage attributes for pulses prepared food for household use and commercial.	Findings/outputs from these studies are described in section 4-Research synthesis
3.2	Roll-out Nutrition Program Intervention	X		23,059 farmers (99.3% F) organized in 1-5 networks and participated in: ➢ nutrition education; ➢ cooking demonstration and skill training programs.	Health extension workers from each district were trained and involved in the process.
3.3	Consumers in urban areas of the 15 districts were introduced to improved cereal-pulse blends	X		Trainings conducted/offered; Two micro-franchises established at Sodo and Butajira; ≥35, 000 consumers used ready-to-eat, pulse-incorporated complementary food products.	Shayashone PLC, GUTS Agroindustry together with project partners involved.
3.4	Process monitoring: Measurements for nutrition program intervention completed	X		The data on intervention of nutrition program was collected, compiled and analyzed	Described in section 4 of 24 months report
3.5	Nutrition end line survey completed; 100% subjects enrolled; survey results analyzed; KABP completed			The survey is completed, data compiled,	Summary results reported in Section 4
3.6	Viable innovation platforms to facilitate market-linked pulse product value chains created.			Training on creating a business plan conducted by Shayashone PLC together with project partners and GUTS agroindustry PLC; micro-finances established at Butajira (Meskan)and Wolaita Sodo towns.	30 females organized as "Likies" sell nutritious pulse=incorporated complimentary snacks.
3.7	Farm Radio International to reach 135,000 HH with	X		246,526 HH reached with radio messages.	Clusters producing bean

	production & consumption messages				established in non-project sites

Objective 4

#	Milestone	Status		Evidence/Indicator	Comment
		C*	IP*		
4.1	Initial steps towards establishing and facilitating women cooperatives in selected kebeles of 15 districts including gender workshop and training	X		45 ToT participants were selected in consultation with 15 Project districts; Participants (35) from BoANR, BoWCA and Regional Cooperative Agency facilitated the establishment.	Summary of the trainings described in Annex II
4.2	Gender-specific training workshop on processing and markets conducted, report disseminated	X		Two gender specific workshops conducted; Gender specific training provided through farmers field days, nutrition education, micro-franchising initiatives; Manuals developed.	Gender sensitization workshop conducted December 10-11, 2015: 65 participants; and December 25, 2017: 85 participants including H.E. Minister of Women and Children Affairs, Regional Head BoWCA and experts, zonal and districts offices of the project sites.
4.3	Process monitoring tools developed and shared that would ensure that the CIFRSF team are mainstreaming gender in their respective activities and scaling-up approaches	X		Three articles published; Four (4) progress reports presented showing the activities, achievements and challenges presented on the PSC meetings.	
4.4	Specialized training in finance, marketing, and value chain to address the needs of poor rural female farmers (i.e at least 3 women leaders from each of the 15 districts offered 5 days intensive training).	X		One businesses modeling TOT training was conducted (45 men and women from district agriculture, cooperatives and women and children offices)	Capacitating experts of public offices facilitated/helped addressing poor rural female farmers.
4.5	At least one women cooperative per kebele (for a total of 60 kebeles) for joint learning, negotiation and marketing their pulse-based	X		Three women cooperatives (45 members) established; Two women micro-franchise groups (30 members) in Wolaita &	Women cooperatives organized under micro-franchise are selling pulse-based blend products;

	products operationalized and facilitated			Butajira to sell pulse-based products.	Regional BoWCA agreed to support the initiative and take forward.

Objective 5

#	Milestone	Status		Evidence/Indicator	Comment
		C*	IP*		
5.1	High level workshops (final stakeholder workshops) organized and facilitated	X		Dissemination workshop 0n 22-23, February 2018 and proceedings shared;	A total of 147 participants including the Canadian Ambassador to Ethiopia; UofS project team, federal and regional office heads, research organizations, NGOs, private and public stakeholders and farmers.
5.2	Final project evaluation and impact assessment	X		Common bean and chickpea impact assessment conducted; The result was presented at the dissemination workshop; Final write-up and documentation underway; Adoption and uptake of the chickpea was significantly improved by the intervention.	Livelihoods of the farmers in the intervention kebeles improved through chickpea production.

4. Synthesis of research results and development outcomes

4.1 Objective 1: Sustainable pulse production and associated seed production and delivery systems: Innovation I – Packages of Practices and Seed

The objective of the activity was to develop sustainable pulse production and associated seed production and delivery systems in 15 districts of Southern Nations, Nationalities and Peoples' Regional State (SNNPRS). The project sites and participating farmers were selected by Regional Bureau of Agriculture in consultation with the Project Steering Committee. This activity was aimed at expanding production of selected common bean and chickpea varieties using improved packages of practices to cover fifteen districts (woredas) during the project life time (March 2015-March 2018). A total of 51,068 farmers were engaged in common bean and chickpea seed and grain production.

The main interventions were:

- Capacity building of Subject Matter Specialists (SMS) from each district and Development Agents (DAs) of the selected Kebeles;
- Selection of location-specific high yielding chickpea and common bean varieties and improved agronomic and soil management practices for their production;
- Seed production by groups of farmers on clustered farms (Best-fit Extension Approaches);
- Grain production of the selected varieties using small package (2 kg of seed) approach.

4.1.1 Seed production using clustered farms

Farmers' Field-based Clusters (Seed Clusters): Model–follower and Farmers and Field-based Cluster approaches, are based on the assumptions of mutual learning, enabling and capacity building. The Farmers' Field-based Clusters approach empowered farmers to adopt seed production of high yielding varieties and applying the improved practices to increase production per unit area and improve food and nutrition security. Farmers were trained by Subject Matter Specialists (SMS) and District Development Agents (DAs) to effectively adopt the complex set of practices. The likelihood of adoption of new agricultural technologies is high when farmers receive the same information from diverse sources that include extension systems and market actors, and social networks (Section 4.2). This has in turn triggered more farmers to venture into multiplication of planting materials, thereby increasing the number of suppliers of improved varieties and diversifying sources of income.

Fifteen (15) farmers in each project kebele were selected to form three clusters per kebele, each cluster having five individual farmers who contributed 0.25 hectare of land each. However, in some districts (Silti, Meskan and Sodo), the project, along with BoANR, managed to form a cluster consisting of 15-30 farmers. Twenty kg of selected chickpea and common bean seeds (Habru, Arerti and Teketay for chickpea, Hawassa-dume and Nasir for common bean), which were identified through participatory variety selection (PVS), were provided to 1854 (305 F) farm households (371 clusters for chickpea) and 1470 (202 F) farm households (294 clusters for common bean). Consequently, 3324 (507 F) farm households participated in seed production of the two crops during the project life. Thirty-seven tons of basic and certified common bean and 46 tons of chickpea seeds were used. A total of 83 tons of NPS containing blended fertilizer and 1470 packets of bio-fertilizer for chickpea (125 g each) were provided to the seed producing farm households. Seven hundred eighty-one liters of insecticide were also delivered to the chickpea seed producers to control "Chickpea African Bollworm" during the life of the project. The inputs increased productivity of chickpea and common bean, on average 0.5 and 0.3 t ha^{-1} respectively, on field of 51,068 farm households, whereas farmers who did not use the insecticide, or applied it at the wrong time, got almost no grain yield from their chickpea fields.

The project made successful efforts to ensure sustainable community-based seed production and delivery system. The seed producing clusters are undertaking seed business with a view to make profit. This could motivate the farmers to sustainably engage in seed production and delivery system. The price gap between pulse seed and grain is additional motivation for famers to focus on seed production. The project has also created market linkage and access to extension for seed producing farmers. It has paved the way towards Integrated Seed Sector Development (ISSD): such initiative links informal and formal seed systems; creates enabling environment for public and private sector involvement; and improves partnership among seed sector players e.g., farmers, seed enterprise.

The innovation has been adopted by some district agricultural offices such as Sodo and Silti through collection of revolving seed of the previous year's harvest to scale-out and reach more farmers without the intervention of the project. For instance, 51 farmers were clustered in Sodo district and planted chickpea during 2016 and 2017 cropping seasons.

Additionally, Farm Africa (NGO) adopted the experience of the CIFSRF project and provided chickpeas to farmers in Halaba area, who lost their maize due to drought in 2016. Chickpea was not considered to be viable in this area but now serves as a risk averting crop. The farmers planted chickpea when the rain started in August. The CIFSRf project is therefore credited for introducing chickpea to this area.

4.1.2 Grain production using small packages

A small package of 2 kg of seed of selected common bean and chickpea varieties was provided to farmers to demonstrate the productivity that could be obtained by using modern pulse varieties and best practices. The best common bean varieties, which were identified through participatory variety selection, were Hawassa-Dume and Nasir (Nasir was used only during the 2015 growing seasons). Habru & Arerti were the chickpea varieties used to reach an extended number of farmers. A total of 18,627 (6,720 F) farm households for common bean and 29,117 (14,170 F) farm households for chickpea participated in grain production. Consequently, 47,744 (20,890 F) farm households were reached through employing the 2 kg approach during the project life. This small package (2 kg) approach has now been adopted by other project partners such as the Regional Bureau of Agriculture and Natural Resources (RBoANR) and South Agricultural Research Institute (SARI) as an effective way of introducing high yielding varieties of different crops. For instance, the Silti district provided 306 farmers with 2 kg of a high yielding common bean variety (Hawassa-Dume) during the 2017 "belg" cropping season from the revolving seed. This enabled the farmers to use the improved varieties and harvest a better yield, as the new variety gives higher yield compared to the local ones and also fits into double cropping farming. Producing two crops from the same piece of land (double cropping) has been introduced by the CIFSRF project to project sites, and it is now considered as a policy issue whereby the region recommends chickpea production only as double cropping. Formerly, farmers used to keep their fields idle during the main rainy season to use for growing chickpea with residual moisture after the rain stops.

Overall, a total of 51,068 (20,097 for common bean and 30,971 for chickpea) (Fig. 1) farm households directly benefited from growing pulse seed or grain or during the project life. Out of the total farm households participating in seed and grain production of chickpea and common bean technologies, 42% (21,397) were female farmers.

4.1.3 Best Production Packages

Agronomic (Management) Practices: Subject Matter Specialists (SMS) and Development Agents (DAs) from the 15 districts received training on improved agronomic packages including: land preparation, optimum tillage practices, sowing time, seeding rate, fertilization, weed management, pest control and harvesting. The DAs took the responsibilities of transmitting the knowledge gained from the training to farmers of their respective kebeles. Additionally, "Farmer field days", often including demonstration plots, were used for providing agronomic information to producers. Farmer field days were held in five districts viz. Damot Woide, Kucha, Meskan, Sodo and Silti from 10-31 December 2016 and a total of 1,130 (296 female) individuals participated including zone and district officials, experts from universities and research and CG Centers, development agents and farmers. In December 2017, four similar farmers' field days were conducted in Damot-Gale, Damot-Woide, Meskan and Sodo districts. The farmers' field days were given media coverage and broadcasted.

Evidence from the Field

"The new technology: planting in row, fertilizer application and inoculation of chickpea, is like new egg type for us with four times yield increments compared to the conventional practice", said farmer Shukur Tadesse on the farmers' field day conducted on 31 December 2016 in Silti district.

Another farmer, Awol Masoro, also said "Initially, we pretended to accept the new technology only to please you but witnessed its benefits. Now we have obtained four times chickpea yield increment (from 0.75 to 3 t ha-1) by using a high yielding variety of chickpea together with improved practices that you provided us".

A feedback workshop, wherein 143 participants from regions and kebele levels participated, was organized at Hawassa University on 10-11, February 2017 to share the successes, challenges and ways forward to sustain the success of the project.

Soil Fertility Management: Conventionally, farmers do not apply organic or inorganic fertilizers to pulse crops. Through the activities of CIFSRF projects, we have identified improved biomass and grain yields of chickpea and haricot bean by applying optimum rates of Diamonium phosphate (DAP) together with inoculation with compatible Mesorhizobium (Call-3 Technical Report, 2014). Consequently, farmers were advised to apply 100 kg DAP or NPS fertilizer blend ha^{-1} together with appropriate Rhizobial strains to chickpea and haricot bean fields. Rhizobial strains EAL 029 and CpM 41, provided by Menagesha Biotech Industry, were used for common bean and chickpea production, respectively, during the growing seasons of 2015, 2016 and 2017. The strain CpM 41, previously named Cp 41, was isolated by a graduate student during the CIFSRF Call-1 project. This strain along with application of 10 kg ha^{-1} phosphorus (P) improved grain yield of chickpea by 50 to 108% (an average yield increment from 1.6 to 2.7 t ha^{-1}). Chickpeas inoculated with this strain also produced higher dry matter yield, which was 19% higher than those inoculated with a commercial strain imported from Canada.

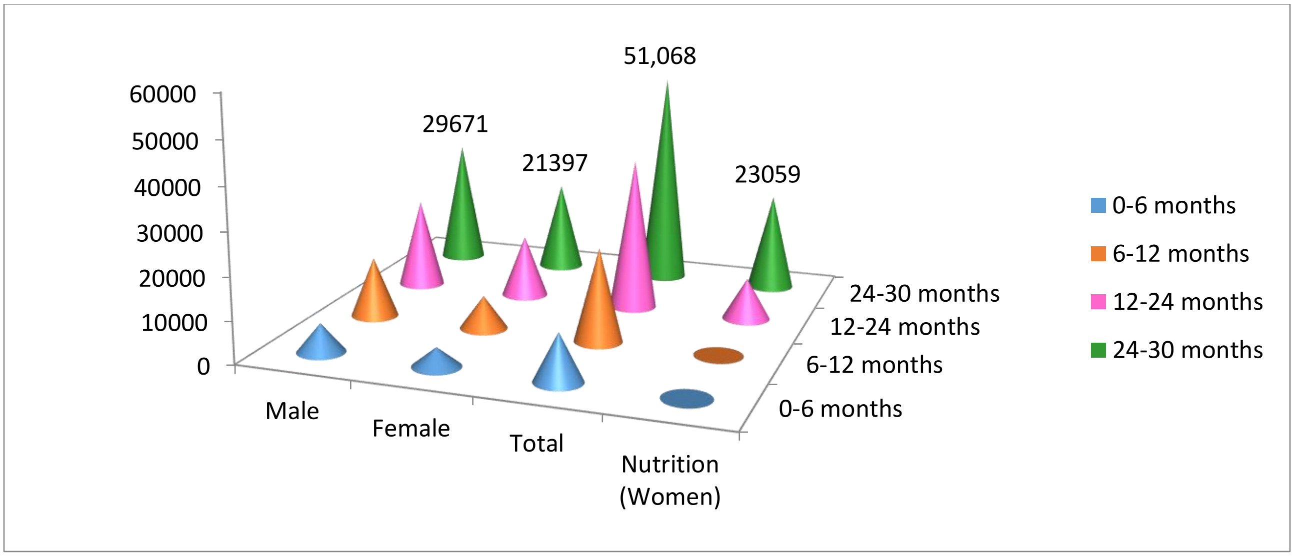

Figure 1. Smallholder farmers benefited from pulse innovations during the project life
***NB: The beneficiaries were reached over 30 months (the cropping seasons during the project duration).*

4.1.4 Participatory Variety Selection (PVS)

To determine the best varieties for each of the new project districts, participatory variety selection (PVS) was carried out in nine districts for common bean and four districts for chickpea. Eight recently developed varieties for each crop were tested, along with a commonly used local variety. Replicated trials were seeded at each site and fertilized according to district recommendations. Grain and biomass yields were determined by researchers, while an average of 28 farmers in each district rated the varieties prior to harvest for maturity, growth habit, pod number and disease tolerance, and after harvest for seed size, seed color and market preference (Annex I).

For common bean, the varieties had variable seed color and size. The variety Wajo had the highest grain yield (average of 3.86 t/ha) in four out of five districts, but as it had a white seed coat, it was not rated highly by the farmers because of the market preference for red seed coat in most districts. The exception was in Sodo district, where farmers had previously grown white seeded varieties for the market. The next highest yielding varieties, Hawassa Dume (2.75 t/ha), SER-119 (2.65 t/ha), SER-125 (2.65 t/ha), and Nasir (2.3 t/ha) were red seeded and were rated the highest by the farmers in most districts. The common local variety, Red Wolayta, was the lowest yielding in most districts (average yield 1.9 t/ha). In the high rainfall year of 2016, the upright growing varieties, Hawassa Dume and Nasir, performed much better than low growing varieties, which rotted in the wet soil conditions. Thus, there is now a large demand for these two varieties in the project districts and they have been the varieties that have been increased in the seed production clusters of the project to attempt to meet this demand.

For chickpea, there was less consistency in the grain yields of the different varieties over the districts as than was found for common bean. The kabuli variety Habru was consistently the top-rated variety by the farmers, but it was only intermediate in mean grain yield (2.4 t/ha) in most districts. Women farmers expressed a preference for the desi type varieties, as the seed coats were more easily removed in food preparation. In 2017, excess moisture in one district led to an infestation of Ascochyta blight. This heavily damaged the desi types, but the kabuli types showed a high level of tolerance to the disease and produced high yields. In three of the four sites, most newer varieties out yielded the local variety by average yield increments of 45, 50 and 70% at Kucha, Halaba and Damot-Woide districts respectively . Based on data from the PVS, the seed production clusters of the project increased seed of the kabuli varieties Habru and Arerti, and the desi type Teketay to meet the increased demand.

In conclusion the PVS determined the farmer preferred varieties for each district of the project. The trials demonstrated a clear advantage of newer varieties over the local varieties. The increased demand for the preferred varieties was at least partially filled by the seed increases done by the seed production clusters of this project.

4.1.5 Response of common bean and chickpea to blended fertilizers and bio-fertilizers in selected districts of southern Ethiopia.

In recent years, a number of new blended fertilizers and Rhizobium inoculants have become available for use by farmers in Ethiopia. The goal of this study was to evaluate the effect of addition of these new fertilizers on the grain yield of common bean and chickpea in four districts of southern Ethiopia. In 2016 and 2017, replicated field trials were conducted using various blends of N, P, K, S, Zn and bio-fertilizer (inoculant), and included a nutrient omission check (Annex I).

For common bean, significant differences in grain yields among fertilizer treatments were not found at some sites, likely due to adequate soil nutrient levels. At other sites, beans grown with multi-nutrient blends produced higher grain yields (increments of 26, 60 and 107%) at Taba, Gacheno and Shone respectively, as compared to the N only treatments, indicating soil nutrient deficiencies. At Hawassa sites, grain yields were increased by N and P applications, but not for the other nutrients, nor from the addition of Rhizobium inoculant. Across all locations, the addition of biofertilizer (inoculant) increased biological yields.

Similarly, the effects of starter nitrogen, phosphorus fertilizer, Rhizobium inoculation, and their interaction were tested on yield performance of chickpea at three locations (Halaba, Taba and Damot Woide) having different agro-ecologies and soil types. A factorial experiment including starter nitrogen fertilizer consisting of 20 kg N ha^{-1} and no nitrogen; three levels of phosphorus fertilizer (0, 10, 20, 30 kg P ha^{-1}); and rhizobium inoculation consisting of inoculated and non-inoculated treatments was conducted in randomized block design with three replications.

Significant differences in grain yield and above ground biomass due to the main factors (starter N, P and inoculation) were not found at all sites. However, the three-way interaction (nitrogen x phosphorus x Rhizobium) showed significant effect on above ground biomass yield at Damot Woide and Taba locations, whereas none of the main factors and the interaction effects resulted in significant differences in grain yield, straw weight and above ground biomass of chickpea at Halaba. The absence of response to the inputs might be due to the fertility status of the soil and intermittent drought during the growing season.

Additionally, Four MSc graduate works on; soil characterization, chickpea varieties cultivated as double cropping, use of blended fertilizers on chickpea, and use of blended and bio fertilizers on common bean were conducted under this objective. The results from the performance of chickpea varieties grown under double cropping in Damot Gale district indicated significant effects of double cropping system and chickpea cultivars on grain yield. The highest grain yield (2.83 t/ha) was obtained from growing chickpea after fallow while the lowest (1.75 ton/ha) was from chickpea after common bean. The Mastewal variety produced the highest grain yield (2.80 t/ha), whereas the lowest yield (1.68 t/ha) was obtained from the local variety. An interaction between chickpea cultivar and cropping sequences also significantly influenced the grain yield, whereby the lowest grain yield (0.99 t/ha) was recorded when the local variety was planted after haricot bean while the highest grain yield was from Mastewal after fallow (3.16 t/ha) with the latter having a 219% yield advantage compared to the former. However, growing the chickpea variety Habru after maize gave the highest marginal rate of return (2946%) indicating that for every 1.00 Birr invested on planting the variety Habru after fallow an additional 29.46 Birr was obtained (Annex III, Scientific Writing Report).

The results summarized above are from the research of these graduate students (Annex III, Scientific Writing Report).

4.1.6 Chickpea and Common Bean Impact assessment: Impact of adoption of chickpea and common bean varieties

A total of 975 farming households from 13 project districts, each district consisting of 2 kebeles (1 intervention and 1 control) were randomly selected for the assessment. From the intervention and control kebeles, 35 and 40 households respectively were considered. Female headed households' representation in the survey was 17%, which is in line with the national survey results, and the family size did not differ between the intervention and control kebeles. About 40% the households in both groups were quite poor in terms of asset ownership.

The results showed that 71% of the respondents in the intervention kebeles received an improved variety of chickpea (kabuli type) for the first time from the project, whereas the local market and neighboring farmers were the main seed sources for the control kebeles. The productivity of chickpea was slightly higher (on average 0.1 t/ha) in the intervention kebeles as compared to the control. The use of small packages (2 kg) without the required inputs by the majority of the respondents was the reason for small differences in productivity of the crops between the intervention kebeles (using improved varieties) and the control (growing mainly local varieties). The adoption of improved chickpea varieties was associated with less vulnerability to food shortage and higher aggregate household level income, whereby the effect was more pronounced amongst female headed households and in the intervention areas. About 87.6% of the households currently growing chickpea are willing to adopt and continue to grow the improved kabuli type chickpea using its improved package of practices.

With respect to the importance of common bean, the intervention areas do not seem to be much different from control areas, as the crop has been produced for so many years in the region. However, the practices of production and the varieties of common bean being produced varied, and the average productivity was higher by about 0.16 t/ha in the intervention than the control kebeles. The respondents indicated that the sources of improved common bean seeds (Hawassa Dume and Nasir) for the first time use in the intervention kebeles were CIFSRF project (50% HHs) and the district office of Agriculture and Natural Resources (35%). This indicates that 85% of the respondents in the intervention kebeles received the varieties from CIFSRF project, since the district offices were project partners that made the first distribution of the improved seeds on behalf of the project. On the other hand, the office of Agriculture and Natural Resources (40%), local market (28%) and neighboring farmers (17%) served as sources of common bean seeds in the control kebeles. A high adoption rate (99.4%) and considerable interest to continue growing the improved common bean varieties were noted from respondents in intervention areas, whereas only 67% showed such interest in the control kebeles.

4.2 Objective 2: Identify, test and promote various scaling-up/out approaches and incentives for wider impact

Best-fit Extension and Communication Approaches:

The best-fit approaches including: model follower farmers (MFF); Farmers' field-based clustered large-scale demonstrations (FFCLSD), and farmers' primary cooperatives, were identified through field studies conducted by ICRISAT (details in 24-month Technical Report). These approaches were followed in the execution of the scaling up activities.

Additionally, farmers' field days, trainings and radio broadcast (Farm Radio International) were also employed as best-fit extension and communication approach.

Farm Radio International (FRI): Information communication technologies (ICTs), is a creative approach led by Farm Radio International that combined radio and video to reach listening groups within the project sites and beyond. Participatory programs, led by local radio broadcasters, were designed to promote improved agricultural technologies and approaches. 135,000 farmers, (40% expected to be females), adopted the promoted technologies contributing to food and nutrition security in the region. The project's support enabled consistent use by farmers of the information provided to increase their yield, promote crop diversification and consider environmentally-sensitive technologies. The economies of scale, gained from the collaboration with FRI, meant that the project was able to develop a variety of media including print and radio to support traditional extension approaches, including demonstration plots, recipe demonstration and nutrition education and training days (see objective 5). All campaign materials were based on the same messages across all the media used by the project (farmer's field, nutrition education). Overall, there was increased farmer awareness and demand for higher yielding varieties of chickpea and haricot beans evidenced by inquiries about sources of improved materials received on the interactive radio and mobile platforms during the joint campaigns. Listeners were found both in project target districts and others.

4.2.1 Evidence Generation for Wider Scaling of SPIFoNS Innovations

The ICRISAT team generated evidences from nine project districts (Silti, Sodo, Meskan, Wolayita, Abeshge, Boricha, M.Badawacho, Hulbareg and Hawassa Zuriya) for better understanding of the project's progress. The team was also involved in partners' feedback workshops, platform meetings and product launching events, where participants from region to kebele levels came together to share the progresses, challenges and way forwards. In the process, there were action-oriented discussions with farmers, woreda officials, researchers, and other potential scaling partners. Majority of stakeholders gave their support to the improved variety seeds and nutrition interventions offered by SPIFoNS project. Evaluations of project's progress in late 2016 and early 2017 were positive, providing useful feedback, insights and recommendations. As part of ensuring sustainability and institutionalization, there were also assessments on how the project technologies be institutionalized, mainstreamed and aligned with local planning system. The generated evidences can shape future course of actions: mainly, what it takes to provoke, promote, and implement system change towards pulse-centered strategy.

In most intervention districts, introducing chickpea as a double crop offered additional benefit to many farmers and helped them mitigate risk in case the preceded crop failed. A survey revealed that a project participating farmer in Sodo and Wolayita districts earns an average extra income of 3500 Birr per annum from chickpea production. Farmers' adoption of chickpea made possible the utilization of slack labor and free land--paving the way for sustainable intensification. For severely land-constrained farmers, which is usually the case in southern Ethiopia, this has created access to land, which otherwise would have been left idle after being utilized by cereals. In addition to the income effect, farmers also strongly pointed out the food and nutritional benefits of growing chickpea.

Haricot bean and chickpea productivity has significantly increased in the intervention districts compared to the control districts. The project helped farmers in potential areas improve their chickpea yield from 10 to 32 quintals/ha. Thus, farmers' response to the varieties in project and surrounding districts is admirably high. There is excess demand for seed to the extent that market-oriented farmers took the initiative to allocate land and buy improved seeds. Now most farmers recognize the pivotal role of seed and packages of practices in agricultural development. During the field visits and focus group discussions, farmers expressed their interest and shared their success with other farmers.

According to farmers' responses, the capacity development and awareness creation efforts helped farmers improve their Attitude, Knowledge and Practices (A-K-P). The radio program, which was broadcasted by FRI in collaboration with FANA radio, had a wide coverage coupled with considerable impact on farmers' understanding of the agronomy and consumption of pulse crops.

4.2.2 Emerging Lessons and Barriers of Scaling-Out and Adoption

There was high turnover of staffs at woreda and kebele levels that made capacity building efforts less successful. Most of the SMS and DAs, who received training related to the project technologies, leave their post before transferring the acquired knowledge and skill to the farmers. The new assignees often lack the skill and project context to effectively coach and support farmers. The project provided repeated trainings to overcome the gaps.

The different project districts have different cropping calendar. Thus, the project had to fulfil the input requirements based on farmers' demand. For example, the late arrival of seed in Abeshge district contributed to waterlogging in 2015. The input delivery in 2016/17 production season was on time and seeding was done at the right time. Overtime, farmers and DAs became more familiar with the technologies e.g., in Meskan, and Wolayita, farmers' preference for Hawassa Dumme variety has considerably increased.

The 2-kg seed provided to grain producers often circulate within the community using informal dissemination system. The scheme improved access to seed but circulating the seed might reduce future productivity, maybe through disease spread and/or reduced productivity. Additionally, there was high prevalence of pest and disease in some districts, especially on chickpea production. In Kucha district, there was a complete damage of some farm fields due to pod borer. Therefore, monitoring visits to communities and fields need to be undertaken on a regular basis in chickpea production. The project team also advised DAs and farmers to secure chemicals to control the pest whenever they are planning to produce chickpea.

4.3 Objective 3: Expand use of pulses in household-level food preparation and commercial production of pulse-cereal complementary food

I. Nutrition Education: partnering with government's health extension program through the Bureau of Health (BoH)

The nutrition education intervention consisted of training sessions on improved Infant and young children feeding (IYCF) practices and the consumption and processing of pulses for mothers and households, especially young children, with participatory cooking demonstrations. This enabled;

- ✓ The dissemination of culturally acceptable and feasible complimentary feeding practices which were field-tested and adapted to the needs of the community.
- ✓ Caregivers learned how to prepare pulse-based food through home-based processing and diversifying locally available foods to improve children's nutritional status in combination with good hygiene and health practices.

Two rounds of the nutrition education intervention were implemented in a total of 52 villages in 15 districts of SNNP region. The first round was conducted from April 2016-December 2016. Second round was during February 2017 to August 2018. A total of 23,059 beneficiaries were involved in nutrition education by CIFSRF project during the three years project (Fig 1).

II. Nutrition education materials

To support behavior change, a ToT manual for health professionals (22 manuals) and Health Extension Workers (94 quick guides) and posters for women HAD (Health Development Army) were prepared. These materials which encouraged the adoption of positive behaviors were developed by the project. More than 3,810 copies (2075 on dietary diversity and 1735 on household pulse processing techniques) were disseminated to caregivers, households, and communities.

III. Research study:

Studies 1 & 2: To assess the effectiveness of nutrition education on farming households, two cross-sectional nutrition surveys (baseline and end line data) were conducted at different time points in households from nutrition education round 1. Between the surveys, an intervention consisting of five interactive nutrition education sessions and cooking demonstration was conducted. The researchers collected data on knowledge and practice of pulse processing, consumption and dietary diversity (24-h recall). The sample comprised 1850 households with children ≥6-23 months of age at baseline and 1449 at end line.

Mean scores concerning knowledge and practice regarding pulse consumption and processing was significantly increased at the end line. At baseline, the mean (± SD) maternal knowledge score was 2.87 ± 1.86, whereas at end line, the knowledge score was 5.2±1.5. After the nutrition education there was a significant increase in maternal knowledge scores in the end line ($P = 0.0001$). Mother's practice score related to the use of pulse in complementary food preparation and processing was increased from 3.02 ± 1.6 at baseline to 5.6±1.7 end line ($p < .001$).

The education intervention also resulted in improvement of children's dietary diversity. Nearly all children aged 6–24 months received grains, roots or tubers at baseline as well as at end line (>90%). Legumes, Vitamin A rich foods, milk and milk products, as well as other fruit and vegetables were the second most consumed foods in both surveys. At end line, a significantly higher proportion of children consumed legumes, nuts and seeds (83.0%, v. 56.4 %, P = < 0·001), dairy products (65.7% v. 59.2 %, P = 0·001), vitamin A-rich fruits and vegetables (82.0% v. 57.5%, P < 0·001) and other fruits and vegetables (72.1v. 59.7, P = 0·001). There were no significant differences in the proportion of children who consumed grains, roots and tubers and eggs in the end line survey (Fig.2). There was a significant difference in diet diversity of infants and young children. In the post-intervention, a greater proportion of children had more diet diversity than at the baseline.

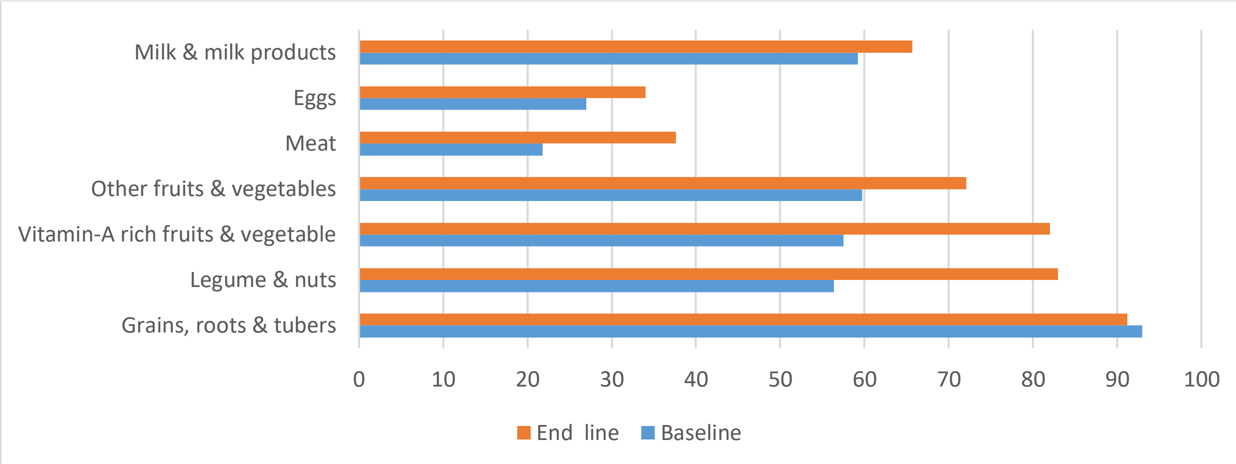

Figure 2. Food consumption pattern among children 6-24 months in rural districts of SNNP region, Ethiopia, at baseline and end line

Study 3: Effects of Pulse Nutrition Education on Lactating Mothers' Knowledge, Attitude, Practice (KAP) and Nutritional Status in Sidama Zone, Southern Ethiopia

The aim of this study was to assess the effects of pulse nutrition education on lactating mothers' KAP and nutritional status. A cluster randomized controlled community trial was conducted. A total of 770 (385 in each intervention and control group) lactating mothers were included in the study. The intervention (recipe-based comprehensive pulse nutrition education) was given for nine months. Measurements (questionnaires and mid-arm, upper-arm and circumferences (MUAC) to test malnutrition were done at baseline and at nine months. For most of households in both groups (87.0% intervention and 90.6% control), farming was the main source of income, and for these households, 91.6% grew cereal crops and 82.5% grew pulses (mainly haricot bean, 87.1%). The mean diet diversity score of lactating mothers calculated out of 12 food groups was 4.40 (1.60). And the mean (SD) MUAC (cm) measurements of lactating mothers in the intervention and control group was 21.72 (2.11) and 21.74 (2.08) respectively. Over all 4.8% and 31.8% of lactating mothers developed severe acute malnutrition (MUAC<18cm) and moderate acute malnutrition (MUAC=18-21cm) respectively. Regarding their KAP at baseline in both groups, few (3.8% intervention, 2.7% control) mothers were knowledgeable, the majority (76.2% intervention, 78.7% control) had a neutral attitude about pulse and pulse-incorporated food consumption and most (92.7% intervention, 93.1% control) did not practice household pulse preparation and processing techniques. The two independent samples t-test showed significant improvement (P-value<0.05) in mean KAP scores and MUAC measurements of the intervention compared to the control groups at the end of the intervention. This suggests that pulse-nutrition education intervention is effective in improving the diet diversity of lactating mothers so as to improve their nutritional status.

Study 4: Effect of Pulse-focused Nutrition Education on Knowledge, Attitude and Practice (KAP) of Mothers and Fathers towards Nutritional Status of Children 6-23 Months in Halaba Special Woreda, Southern Ethiopia

The objective of this study was to compare the effect of pulse focused nutrition education on KAP of mothers and fathers towards nutritional status of children 6-24 months at Halaba special woreda, SNNPR. The results showed fathers' involvement in awareness creation about the importance of pulse consumption brought a promising increase in the level of knowledge and attitude of mothers towards pulse crops use in complementary feeding compared to providing nutrition education only for mothers. Thus, fathers should be viewed as potential agents for implementation of child feeding/nutrition specific.

Three MSc graduate students' researches including effects of peer-led nutrition education intervention on school aged children's knowledge, attitude, practice and nutritional status; effectiveness of government structure in grassroot level on knowledge transfer of pulse use; and comparison of the effect of nutrition education on knowledge, attitude and practice/KAP/ on household pulse consumption among male and female farmers were conducted under this objective. The results are summarized and attached to this report (Scientific Writing Report).

4.4 Objective 4: Create capacity and improve women farmers' access and control over resources to enhance their participation, productivity, income, and nutritional status

The gender integration component of this CIFSRF project focused primarily on operationalizing the gender strategy, which was developed and approved in 2015. During the project life, the gender capacity was enhanced by gender research through multiple pathways: hiring a lead gender scientist and postdocs; allocating sufficient resources to support gender training workshops to implement the business micro-franchising model; and development of a new model and integrating it into the current women cooperatives for the sale of nutritious pulse foods in semi urban areas. Additionally, the project has also sponsored female graduate students at the MSc (5) and PhD (1) levels to enhance gender analysis skills.

As a across cutting issue, the gender program has implemented a transformative approach (agri-food processing-nutrition-business) that focuses on changing the organizational and social norms by taking the strategic needs of women into account so that they will have equal access and control over resources (land rights, income, education, health, etc.).

Intervention Strategies:

- During the project period, best agronomic practices for haricot bean and chickpea production were developed and disseminated to male and female farmers across project sites. Model Follower and Farmer Field-Based Cluster approaches (based on assumptions of mutual learning, enabling and capacity building, and use of innovation platforms) empowered farmers, especially women, to adopt improved agronomic practices for improved food and nutrition security. Evidence from the field indicated that farmers adopt new agricultural technologies when they receive the same information from many diverse sources that include extension systems, market actors, and social networks (ICRISAT, 2017). Providing 2 kg of chickpea seed to close to 50,000 farmers who hadn't previously grown chickpeas was more popular with women farmers than with men, as the small area planted could be more easily managed by women. This improved decision making and income for women in farm households.

- A lack of availability of quality seed of improved varieties has been a roadblock to introducing best practices to improve profitability for farmers. Over the years, our projects have improved the availability of quality seeds of modern market preferred varieties of chickpeas and haricot beans. This increase was accomplished through farmer participatory trials and the establishment of farmers' seed production clusters consisting of five individual farmers contributing 0.25 hectare of land each in order to support scaled up seed production. In 2016, improved varieties of chickpeas and haricot beans were planted specifically for seed production in 13 and 15 districts in SNNPR, respectively. This initiative led to the production of 180 tons of certified chickpea seed in 2016 alone. To date, a total of ten primary seed production cooperatives have been established, five of which are certified. Three of these are women-only cooperatives.

- Establishing value-addition and pulse-based food processing: During the project period, the UofS-HU partnership partnered with Guts Agro Industry PLC, an ISO 222000-certified food processing company in Ethiopia, with whom we have developed commercial-scale prototypes of pulse-based food products, extruded snacks and flours, from chickpea-maize, chickpea-barley and chickpea-sorghum blends. Products are also being developed from bean; some are quite new and will require more promotion and sensitization among consumers. Preparation of extruded products from such blends is new to Ethiopia. Quality parameters such as expansion ratio, textural analysis, proximate analysis, content of anti-nutritional factors, and sensory acceptability have been assessed. Five women groups have been organized to market and process these nutritious food products, and have received different phases of training, coaching, and follow-up mentorship. Under the micro-franchising of Guts Agro Products, women buy the products at wholesale prices and sell at a greater than a 10% margin to generate income for their households. This model has been a very successful women enterprise; in part due to support services provided by the Government of Ethiopia. While support has had a positive impact on the women's revenue, further training and technologies are needed to help position the women in the processed product market. Some women's groups still face challenges, such as maintaining a steady supply of raw and processed products; obtaining adequate training and transport; and expanding sales points. Establishing women-based organizations is one of the key strategies of the current project to address women's unequal participation in production and marketing. Future projects will seek out opportunities to engage adolescent girls' employment in the food-processing environment, promoting women entrepreneurship, and fostering an enabling environment for more women enterprises to prosper.

- Nutrition Education and Behavior Change Communication: Several studies conducted during the project period showed nutrition education as an important component of the nutrition- and gender-sensitive value chain for improving dietary habits and food choices of the undernourished. Studies conducted in the project region documented the importance of nutrition education in increasing pulse consumption [Henry, Whiting, Regassa, 2015; Negash, Belachew, Henry, et al, 2014); among adolescent girls (Roba, et al, 2015;] for improved nutritional outcomes of children; women, and school children (Mastewal, Henry, Samson, Nigatu, 2017) and adolescent girls. Nutrition education also influenced caregiver preferences towards more nutrient-rich pulse foods, intra-household allocation of food to benefit pregnant and lactating women and their children, and other practices related to child feeding, caregiving, sanitation and hygiene, and use of health services (Lombamo, et al, 2016). Global evidence base supports the growing understanding that effective incorporation of nutrition messages is associated with improved nutrition outcomes (Lancet "Maternal and Child" series 2013).

- Two studies published that describes further the integration of gender into the scaling-up process are,

- Esayas Bekele Geleta, Patience Elabor-Idemudia and Carol Henry, 2017, "Scaling-up: Gender integration and women's empowerment in Southern Ethiopia available @ https://www.cogentoa.com/article/10.1080/23311932.2017.1415100
- Esayas Bekele Geleta, Patience Elabor-Idemudia and Carol Henry 2017 The Challenges of Empowering Women: The Experience of Pulse Innovation available @ http://journals.sagepub.com/doi/full/10.1177/2158244017736802

The micro-franchise women are marketing fortified pulse-based products and other food products of Guts Agroindustry. These products are certified for their quality by national and international standards. Besides the qualities, the products are supplied at affordable prices. The 30 micro-franchise women are expected to reach over 10,000 households in the two target towns. Of these household members, most beneficiaries will be children and lactating mothers as Guts Agroindustry products are produced for these target groups. Women Groups were organized to market and process pulse based nutritious food under the project Scaling up of Pulse Innovation in SNNPR. Five Women Groups have been organized and have been going through different phases of training, coaching and follow-up trajectory. A team of Shayashone has been visiting four of the five Women Groups to track latest status between Oct. 15-23. The short note below summarizes the status of the women groups. A recent visit by the Shayashone team reported that in the **Sodo town-cluster (**Wolayita) a group of seven women received coaching and follow-up business training.

The group was formally launched in Feb. 2017; today the monthly turn-over is 15,000 Birr. The Woreda Bureau suggested that this enterprise has been a very successful Women Enterprise. The government is giving them Shade and all the necessary support to continue to do well. They said, "Need more of this kind of intervention". Way Forward: "Need more fast-moving products and the company should arrange transport from Hawassa".

Butajira Cluster, Butajira: Business Group: Micro-franchise of Guts Agroindustry Products; **Number of Women:** 10; Now left 7. **Coaching Rounds Conducted**: Three; **Group Status**: Legally registered and started business. Formal Launching: Launched in Feb. 2017; Latest Status: Monthly turn-over of 2000 Birr, 3 rounds of products. **Comment from Woreda Bureau**: The women have found it difficult to collect product from Hawassa. Besides, not all of them have same passion and sometimes there is a tendency of waiting for each other. The government will provide them shade if they perform better than this. Way Forward: Need more products and company should assist in arranging transport from Hawassa to Butajira. We will continue to monitor and provide support for these groups.

4.5 Objective 5: Develop and facilitate tailored communication strategies and innovation platforms for policy action in scaling-up of pulse innovations

Research on innovation dissemination pathways and diffusion networks was conducted by ICRISAT. Nine project kebeles in 6 districts of southern Ethiopia were selected for the study. These included 135 seed producing clusters, and 45 grain producers. The study assessed the effectiveness of innovation dissemination tools for scaling of legume-based agricultural technologies and nutrition interventions. Data were collected from a sample of 170 participating farmers, representing different scaling-up/out scenarios (24-month Technical Report).

The way in which farmers share information about new technology differ from location to location (Fig 4). In general, the one-to-five government structure (1:5) is found to be the primary technology platform in most study sites. It is a formal network established by the local government, facilitated by kebele administration, aiming at facilitating participatory learning, communication and partnership among farmers. The leader, selected by the team members should be a model farmer and be trusted by the members and recognized as best community mobilizer. However, it is also important to note that this structure may overlap with other informal rural social networks: for example, with Iddir, equb, and debo.

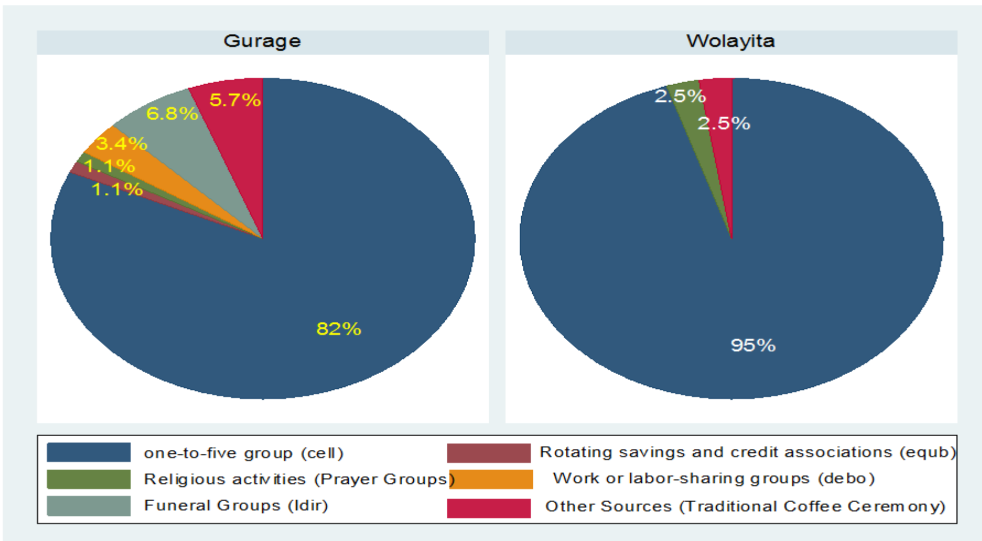

Figure 4: Primary information sources and technology sharing mechanisms

A Technology Diffusion Mapping (TDM) (Fig. 5) was developed to trace how agricultural and nutrition innovations move from farmer-to-farmer and community-to-community. The findings suggest that farmers with better absorptive capacity for technologies are quicker to disseminate the innovations, which supports the Model-Follower farmer approach adopted by the project. Farmers who are food secured and have better access to resources (e.g. land, livestock, off-farm income) were more proactive in sharing good technologies and practices than food-insecure households; thus, justifying the argument to produce more and then disseminate more. On the other hand, those farmers who are producing for subsistence may have the willingness to share but may be limited in their ability to share. About 92% of the households who took part in the dissemination process are non-subsistence farmers. And on average, a farmer participating in the project has donated or gifted 20 kg of improved variety chickpea to family members, 9 kg to labor sharing member, 6 kg to ox-sharing member, 11 kg to friend and 7 kg to neighbors (Fig. 5).

Figure-2: Technology Diffusion Mapping (TDM) for Chickpea and Haricot Bean Varieties

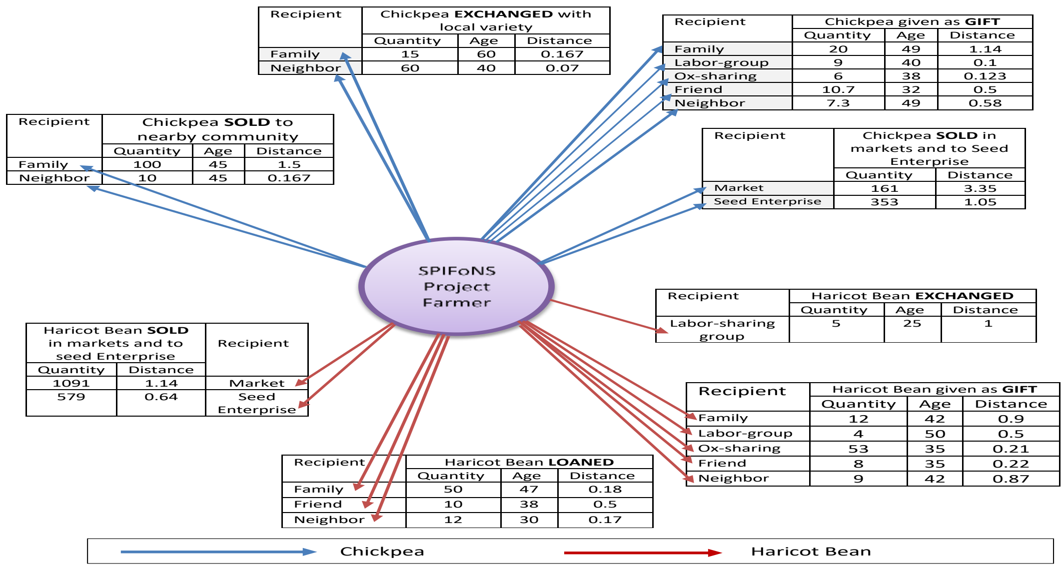

Figure 5: Technology Diffusion Mapping (TDM) for chickpea and haricot bean varieties

4.6 Objective 6: To develop and expand the capacity of partners in integrating agriculture and nutrition

The project provided post graduate training (MSc studies) to candidates selected from partner organizations. A total of 18 MSc students from Bureau of Agriculture (6), South Agricultural Research Institute (3), Bureau of Health (2), Bureau of Women and Children (1), Regional Cooperatives Agency (2), Ethiopian public Health Institute (1) and EIAR and Higher Learning Institutions (3) were enrolled into Agriculture, Applied Human Nutrition, Agri-Business, Gender and Family Study Programs. Three of the 18 MSc students discontinued their studies due to different reasons.

The remaining fifteen MSc students worked in various disciplines; Soils (2), Agronomy (4), Nutrition (2), Food Science (1), Agri-business (6), and their research was conducted with the support of the project. The students were trained on proposal development at the start of their research work and scientific writing upon completion of the data collection. The compiled scientific report, which includes Abstract, Introduction, Materials and Methods, Results and Discussion, and Summary and Conclusions, of every student is attached to this report (Scientific Writing Report).

5. Synthesis of results towards AFS themes

5.1 Increasing agricultural productivity (Availability)

The project increased agricultural productivity by: (1) scaling up of high yielding pulse varieties together with proven packages of practices (agronomic practices and optimum rate of inorganic fertilizer and Rhizobium inoculation); (2) making use of new technology and innovative approaches so that farmers can boost production and profits, while at the same time improving soil quality; (3) providing training to farmers to increase their capacity to feed their households with nutritious foods. Additionally, the project introduced double cropping of chickpea after harvesting the main season cereal crops to utilize the free land and slack labor with minimum residual moisture, which enabled them to get two harvests from the same unit of land. Chickpea was not a major crop in southern Ethiopia but is now considered as a commodity following its introduction by CIFSRF projects (Call 1 & 3) and the scaling up activities by the current project (Call 5). This technology was taken as a policy issue by the SNNP regional government for enhancing chickpea production and productivity in the region.

5.2 Improving access to resources, and/or markets and income (Accessibility)

The project provided men and women farmers (51,068) with improved varieties of common bean and chickpea, bio fertilizer, agricultural inputs (inorganic fertilizer, DAP) and chemicals (insecticide). It also helped the farmers to better utilize their land and get additional benefits from the same unit of land by applying double cropping practices. Moreover, the project sought to empower women through training in marketing, finance and the setting up of cooperatives to sell nutritious pulse foods and as well as high yielding seeds. The Gender Program closely worked with a Shayashone business consultant and GUTS Agroindustry PLC to organize women to increase their income. Two women groups (Likies) have been organized to engage in income generating activities related to pulse products in Butajira and Sodo towns. Additionally, three women only seed producing primary cooperatives (45 female members) were established in Misrak Badawacho district and the regional Bureau of Women and Children Affairs is on the process to organize them as Women Only Service Cooperative. Nutrition education and skills training in recipe development/preparation provided skills in complementary food preparation for young children. The initiatives helped to improve women's decision-making skills and by extension household consumption of nutritious foods. These achievements indicate that the project worked towards gender sensitive public-private partnerships in addressing women and children problems.

5.3 Addressing bottlenecks and constraints to markets (e.g. financial, institutional, gender constraints, youth engagement).

The project organized 3,324 common bean and chickpea seed producers (male and female farmers) and facilitated marketing of their production with South Seed Enterprise with a stated additional 15% premium price, showing that the farmers were linked with the market for their production. A total of nine primary pulse seed producing cooperatives (3 women only) have been established to date. The regional Bureau of Agriculture and Natural Resources is working on linking them to the nearby unions and establishing, at least, one primary cooperative in each district in cooperation with the regional Cooperative Agency. The three women only seed producing primary cooperatives (45 women farmers) were established in Misrak Badewacho after receiving necessary training and production inputs. Female farmers within cooperatives have received training on developing a business model, accessing finance, and marketing. Importantly, some of the cooperatives are able to link new females joining the cooperatives with such access.

5.4 Contributing to improved income

The project supported the supply of certified common bean and chickpea seeds to farmers organized in clusters. The groups received an additional 15% premium price leading to improved income of the beneficiaries. The micro franchise model of sale for nutritious pulse food by women cooperatives was launched in February 2017 in partnership with GUTS Agroindustry. Through this initiative, pulse-cereal blend food products are now available on a large scale to farm households and urban consumers. The income of chickpea producing farmers was improved through the introduction of double cropping activities. The participating farmers are now able to produce two crops on the same land in one growing season (e.g. 45 farmers produced chickpea in clusters after harvesting maize in Meskan district) and sell the produced chickpea seed at 15% premium price showing the increased income from the same piece of land.

5.5 Improving nutrition (Utilization):

The project worked on scaling-up the adoption of pulse-based food products though nutrition education and recipe demonstrations, and training using behaviour change communication channels. This includes providing training on processing methods and recipe demonstrations through home visits for follow up based on the national health extension program. The main outcome targets are helping more women (directly reached 23,059 farm households, 99.3% female,) and children to have adequate diet diversity, with fewer members of the affected population having macro and micronutrient deficiencies.

Pulse crop production on farms provided with seeds by the project was used for food preparation and consumption, and for sale. Training sessions were provided to male and female farmers in the same settings; in most cases on production, processing, preparation, and consumption. Various business strategies (nutritious pulse-based food products sold through women cooperatives, and traditional recipes were adapted for consumption and use in school feeding program) were tested to ensure market and service provision across the value chain.

5.6 Informing policy

The project engaged policy makers though establishing the regional pulse platform, which was linked to the National Chickpea and Common Bean Platforms. Two policy fora were held in Hawassa and Addis Ababa in 2015 and 2016 respectively. The progresses of the projects were presented at the Chickpea National Platform and Common Bean National Platform in 2016 and 2017. An international engagement was also carried out at the technical workshop held at the UofS in October 2016.

At the request of the regional Bureau of Agriculture and Natural Resources to determine the optimum phosphorus rates for chickpea production for further extension of the best outputs, trials on increasing rates of P for chickpea production were carried out in three districts (Halaba, Damot Gale and Damot Woide). The results were shared and also included in this report. Results were also shared internationally at the Micronutrient Forum in October 2016, Cancun, Mexico, the CIFSRF meeting at the U of S in October 2016, and several other venues. Most members of the project steering committee were also among the higher level regional officials who contribute to the policy in one way or another.

6. Project outputs

a. Capacity building: No. of staff trained or being trained

i. Two PhD (one each from nutrition and food science at HU) who are expected to finalize their works and defend the Dissertations in 2019, 2020

ii. 15 MSc. from partner institutions in different specializations (Soil, Agronomy, Nutrition, Food Science, Agri-business). Ten MSc students defended their theses and graduated, whereas five are expected to graduate in June 2018.

iii. Other trainings and community teaching (pulse production including land preparation, inoculation techniques, sowing time and methods, pest control, nutrition education, gender empowering on different community gathering).

b. Resources/facilities acquired

- ➢ A double-cabin pick up vehicle was purchased for transport to the project sites and other activities of the project;
- ➢ Common Bean Production Guide (Amharic and English versions): with emphasis on southern Ethiopia.
- ➢ Pulse Consumption for Improved Nutrition: A Manual for Training of Trainers;
- ➢ A quick reference guide (poster) on dietary diversity, processing and utilization;
- ➢ Three (3) briefs were developed for dissemination
  - ✓ Seed systems in Southern Ethiopia: Drivers, Players, Barriers and Enabling Environment
  - ✓ Wider Adoption of Nutrition Interventions: Key Lessons
  - ✓ Examining the Scaling-up Approaches: Lessons from SPIFoNS project from Champions

c. Technologies developed and/or transferred

- ➢ Seeds of high yielding chickpea and common bean varieties together with proven agronomic packages and practices (land preparation, fertilizer application, row planting, weed control, pest control and harvesting methods);
- ➢ Inoculation of chickpea and haricot bean with proven compatible rhizobium strains;
- ➢ Introduction and extension of chickpea to non-traditional chickpea producing districts/soils or areas where chickpea production was not considered viable (Halaba in Call 1; Damot Woide and Boricha in Call 5);
- ➢ Introducing double cropping using chickpea in the region; and also to areas practicing mono-cropping of chickpea (Sodo district);

- Seed production through clustering approach
- Cereal-pulse blend food products – snacks, precooked flours, porridges – were incorporated into recipes and demonstrated;
- Improve nutritional status of farm households and pulse-based farming practices using a variety of media and communication strategies (FRI).

d. Research outputs

Number of publications in peer reviewed journals (14)

- Alemneh Kabata, Carol Henry, Debebe Moges, Afework Kebebu, Susan Whiting, Nigatu Regassa, Robert Tyler (2017). Determinants and Constraints of Pulse Production and Consumption among Farming Households of Ethiopia. Journal of Food Research, vol 6 (1), 2017.

- Sheleme B., 2017. Topographic Positions and Land Use impacted Soil Properties along Humbo Larena-Ofa Sere Toposequence, Southern Ethiopia. Journal of Soil Science and Environmental Management; 8(8): 135-147. DOI: 10.5897/JSSEM2017.0643.

- Berhanu G, Whiting SJ, Henry C, Challa F, Belay A, Mulualem D and Green TJ (2017). Assessment of Knowledge, Attitudes and Practices of Mothers' on Pulse Incorporated Complementary Food and Associations with Diet Diversity and Nutritional Status of their Children in Two Rural Districts of Sidama, South Ethiopia.

- Geleta, Esayas Bekele, Patience Elabor-Idemudia, Carol Henry, Nigatu Regassa, (2017). The Challenges of Empowering Women: The Experience of Pulse Innovation Project in Southern Ethiopia. SAGE OPEN, DOI:10.1177/2158244017.

- Geleta, Esayas Bekele, Patience Elabor-Idemudia, Carol Henry, (2017). Scaling-up: Gender integration and women's empowerment in Southern Ethiopia. Cogent Food and Agriculture, DOI:10.1080/23311932.2017.1415100.

- Getahun Ersino, Carol J Henry, and G. Zello. (2017) A nutrition intervention affects the diet-health related pratices and nutritional status of mothers and children in a pulse-growing community tin Halaba, south Ethiopia. Federation of American Societies for Experimental Biology Journal
http://www.fasebj.org/doi/abs/10.1096/fasebj.31.1_supplement.786.39

- G. Lombamo, C. Henry, G. Zello. (2016) Suboptimal Feed Practices and High Levels of Undernutrition Among Infants and Young Children in the Rural Communities of *Halaba* and *Zeway*, Ethiopia. Food Nutrition Bulletin. 37(3): 409-424.

- Henry, C., Fereja, M., Mesfin, A., Whiting, S.J. and Regassu, N., (2017) Empowering women and women-headed households through production, nutrition education and consumption: Lessons learned from pulse-based nutrition sensitive agricultural strategies in Ethiopia. In ANNALS OF NUTRITION AND METABOLISM (Vol. 71, pp. 214-214).

- Hiwot Haileslassie, Carol Henry, Bob Tyler, 2016, Impact of household food processing strategies on anti-nutrient (phytate, tannin and polyphenols) content of chickpeas (Cicer arietinum) and beans: A review. International Journal of Food Science and Technology, vol 51 (9), September 2016, p 1947-1957

- Mastewal Zenebe, Samson Gebremedhin, Carol J. Henry and Nigatu Regassa. (2018) School feeding program has resulted in improved dietary diversity, nutritional status and calass attendance of school children. Italian Journal of Pediatrics 44:16 https://doi.org/10.1186/s13052-018-0449-1

- D. Mulualem, C.J. Henry, G. Berhanu, S.J. Whiting (2016). Effects of Nutrition Education on Promoting Grain Legumes in Complementary Feeding in Wolayita, Southern Ethiopia. Ecology of Food and Nutrition, 2016, 55(3):308-23.
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- F. Teferra Tadasse, Abadi Gebre, Abrehet F. Gebremeskal, and C. J.Henry 2016. Pasting characteristics of starches in flours of chickpea (Cicer arietium l.) and faba bean (Vicia faba L.) as affected by sorting and dehulling practices. African Journal of Food Science, Vol 9 (12), pp. 555-559.

- Whiting, S., Berhanu, G., Henry, C., & Green, T. J. (2017, January). Effect of Nutrition Education to mothers on improved pulse consumption by young children aged 6 – 24 months in rural Sidama, south Ethiopia. In ANNALS OF NUTRITION AND METABOLISM (Vol. 71, pp. 1271-1271).

- Rediet Abera, Walelign Worku and Sheleme Beyene, 2016. Performance variation among improved common bean (Phaseolus vulgaris L.) genotypes under sole and intercropping with maize (Zea mays L.). African Journal of Agricultural Research; 12(6): 397-405.

In-Review (1):

Carol J Henry, Mengistu Fereja, Addisalem Mesfin, Suzan J Whiting; Nigatu Regassa. Infant and young children feeding practice and knowledge of mothers on pulse incorporated complementary food preparation in Southern Ethiopia,

7. Project implementation and management

The implementation of the project was guided by a Project Steering Committee (PSC) in southern Ethiopia. The PSC was chaired by the Vice President for Research and Technology Transfer at HU and consisted of Deputy Heads of Bureaus of Agriculture and Health; Directors of South Agricultural Research Institute and Ethiopian Public Health Institute; Head of the Bureau of Women and Children Affairs; and Managers of South Seed Enterprise; South Farmers' Cooperative Federation and GUTS Agroindustry; and the project PI served as secretary. The PSC looked into overall project coordination, and monitored and periodically evaluated the progress of the activities. The PSC held six meetings during the project life, evaluated the reports and provided advise on necessary adjustments to meet the progress towards the planned milestones. The PSC members and other policy makers participated in Farmers' Field Days conducted on

17 and 18 December 2016 in Meskan and Sodo; 31 December 2016 in Silti; and 30 and 31 December 2017 in Meskan and Sodo districts.

The project had also a Scientific Impact Advisory Committee (SIAC) which is an independent international committee established to ensure the greatest possible development impact and delivery of development outcomes. The SIAC and PSC oversaw the overall progress, reviewed and assessed outputs, and provided guidance. The PSC played crucial roles in the implementation of the project activities by instructing District Agricultural and Natural Resource Offices, Regional Seed Regulatory Department and South Seed Enterprise for timely selection of farmers and fertilizer supply, clustered fields and seed inspection and collection of the seeds produced by clusters, respectively. Additionally, the PSC held successive meetings (December 2017 in Butajira; 03 February 2018 in Adama) and discussed on the exit strategies of the project and shared responsibilities to take forward the results for sustainability (see proceedings of the Dissemination workshop). A MoU on the shared responsibilities is drafted to be signed by the partner institutions.

The two PIs of the project made regular communications through E-mail, Skype, and telephone, which enhanced smooth implementation of the activities based on the planned milestones. The PI and Co-PI of the project from the Canadian side made visits to all project sites in 2016 and 2017 growing seasons and discussed with the farmers on various issues pertaining to the implementation. The Canadian and Ethiopian project teams also held meetings to discuss progress and plans for future activities every year during the project life.

8. Constraints to wider adoption of pulse technologies

Scaling-up is limited by the availability of resources to address requests for seeds and other agronomic techniques, especially from farmers who have experienced the new varieties and others who have seen the results and would like to participate. A female farmer said, “We want more”. Expanded partnerships may be needed to increase seed availability to address increasing demand from participating famers and others. However, the following constraints were encountered during the scaling up activities.

8.1 Pests

When asked about the constraints for the adoption of the new varieties, participants singled out pests, especially on chickpea, as Pod borer (Boll worm) and Fusarium wilt are the main problems in chickpea production in most project districts. Pod borer is an aggressive pest that could not only devastate a field in few days (three to four days) but also could move from field to field rapidly. For example, the fields of individual farmers in Taba kebele are often very close to each other. Farmers said they needed to be vigilant in monitoring their chickpea fields and also needed neighbours who could afford to spray their crop. They also pointed out that it was sometimes futile to spray your field, if the neighbour does not do the same, as the sprayed field could also be infested. If the spray is done on time however, the farmers could benefit from the higher yield and price per unit yield of the new varieties.

8.2 Climate change: drought and heavy rainfall

In the 2015 growing season, temporary drought struck caused by El Nino was the major problem in production of common bean and chickpea. Late onset of rain, poor distribution during the growing period, and drought at the flowering stage caused failure of common bean, particularly at Halaba. The district bureau of Agriculture and Farm Africa (NGO) provided farmers in the districts with seeds of chickpea, thanks to the CIFSRF project that identified the viability of chickpea in the district. However, chickpeas were also affected by drought during seed emergence and growth at Halaba and other sites having light soils.

Figure 2. Chickpea and pepper fields affected by drought in 2015, Halaba site

In 2016, heavy rainfall and flooding were the major problems to common bean production. However, the variety Hawassa Dume, which was used for scaling up across the 15 districts, was not affected by flooding. This variety was tolerant to the heavy floods, as it stood erect during the growing season. Additionally, the variety gave better yield than others and possesses the red seed color preferred on the local market. Consequently, farmers in all districts have been asking for this variety since then.

8.3 Turnover of Experts and Development Agents

Turnover of subject matter specialists (SMS) and Development Agents (DAs) was another challenge in dissemination of the technologies. The SMS and DAs at district and kebele levels respectively, leave for further training or other assignments without proper handover of the project activities. In all such cases, the project made arrangements for training of the new comers, although lag in the speed of the dissemination was inevitable. The other challenges were:

- A variable level of commitment of focal persons (SMS) and implementing partners in the different woredas has resulted in a lack of timely response for certain woredas;
- HEWs were occupied by various tasks (job overburdening) and in some cases considered the activities of the project as secondary and this lack of ownership created difficulty in integration of the activities into formal planning;
- Wider geographical implementation areas with diverse socio-cultural practices;
- Limited number of male participants in nutrition education means that women continue to do the greater share of domestic work in farm households;
- There was also problem in data collection and evidence generation from DAs. Yield figures from some kebeles were highly exaggerated and inconsistent (especially grain producers). Some of the yield figures are difficult to rely on and lead to adverse selection and spurious recommendations.

Annex I

Field Experiments

1. Participatory variety selection (PVS)

Berhanu Abate

The participatory variety selection trials on common bean and chickpea were conducted to identify farmers' preferred varieties that are locally adapted, stable and suitable to the existing cropping systems. The trials were carried out with full participation of farmers at different phonological stages of the crops so that the farmers are able to identify the variety that fits best to their own set criteria.

1.1 Common bean participatory variety selection

Participatory selections of common bean varieties were conducted at nine districts (Halaba, Damotgale, Damot-woide, Misrak-Badewacho, Shashogo, Humbo, Kucha, Sodo and Abeshge) using nine improved and one local varieties. The experiments were conducted on plot sizes of 9.6 m^2 (4m x 2.4m) in randomized complete block design with three replications using spacings of 40 and 10 cm between rows and plants respectively. At planting, each plot received 100 kg DAP or NPS fertilizer per hectare.

The participatory evaluation was done before harvest, at about maturity, considering erect growth, pod number and disease tolerance; and after harvest evaluating seed size, seed color, seed yield and market preferences. Additionally, the yield data were collected and analyzed by researchers.

Wajo, the creamy colored common bean variety, produced significantly the highest yields across the districts, except in Abeshge where it was inferior to SER 119 (Table 1). However, Hawassa-Dume was ranked first by farmers across the sites due to its preferred color (dark red color) which has in high demand on the local market, followed by SER-119 and Nasir (Table 1). However, Wajo was ranked first by the farmers in Sodo district, who later adopted Hawassa-Dume following discussion on the morphology (low growth habit) of Wajo that would perform poorly in high moisture conditions. On average, 28 farmers participated in the selection of the varieties in each district.

The PVS activities on common bean were further carried out in Humbo, Damot-Woide, Shashogo and Kucha districts. The yield performances, ranks with respect to the yield of each variety and farmers preferences are presented in Table 3. The results showed that Wajo variety was superior in terms of the grain yield in three of the four districts. However, the farmers' preferences and selection varied amongst the districts based on their own set of criteria (Table 2).

Table 1. Grain yield (Q/ha) and ranks of common bean based on yield and farmers' preference of the varieties in five project districts

Variety	Halaba	M/Badwacho	D/Gale	Sodo	Abeshge	Mean (Q*)	Yield Rank
Nasir	31.33cd (3)	17.54bc	19.92c (3)	24.30ed	38.90a	26.69c	5
SER-119	33.63c (2)	20.58bc (2)	22.64bc	36.77bc 3	41.20a (2)	31.55b	3
Ibado	28.4de	15.29c	20.16bc	20.13ef	19.87d	20.61d	9
H.Dume	37.50b (1)	21.18b (1)	28.73abc (1)	40.27ab 2	35.63ab (1)	33.17b	2
Wajo	41.78a	29.25a	29.77a	49.95a 1	40.27a	38.6a	1
Remeda	27.7e	18.32bc	21.5c	28.88cde	19.90d	23.32cd	6
SER-125	28.7de	19.62bc (3)	23.98abc (2)	34.70bcd	42.13a (3)	30.69b	4
Tatu	23.1f	18.32bc	23.01bc	22.20e	28.21c	22.89d	7
Local	29.7de	19.44bc	21.00c	11.10f	30.07bc	21.90d	8
Mean	31.32	19.95	23.41	29.81	32.91	27.71	
CV%	5.68	12.06	16.24	21.11	11.55	15.83	
LSD	3.08	5.55	6.58	10.89	6.58	3.44	

*Grain yield figures followed by same letter(s) within a column are not significant at P≤ 0.05, whereas the numbers in brackets indicate the ranking of the variety by the farmers of the corresponding districts.
*Q =100 kg

Table 2. Grain yield (Q/ha) and ranks of common bean varieties at Humbo, Damot-Woide, Shashogo and Kucha districts

Variety	Humbo	D/Woide	Shashogo	Kucha	Mean	Yield Rank
Nasir	9.20bc	19.10cd	30.04c	20.84a	19.80	5
SER-119	10.07abc (3)	20.14bc (1)	29.17cd (2)	24.74a (1)	21.03	4
Ibado	7.81c	16.32de	28.30cd	10.94c	15.84	9
H.Dume	10.76abc	20.66abc (2)	34.03b (3)	23.44a (2)	22.22	3
Wajo	13.89a	23.96a	38.72a	15.63b	23.05	1
Remeda	7.12c	13.72e	18.75e	15.63b	13.81	10
SER-125	13.54ab (1)	23.44ab (3)	30.42bc (1)	22.92a (3)	22.58	2
Tatu	10.07abc	18.75cd	27.08cd	14.34bc	17.56	7
Kat-B9	11.63abc (2)	18.75cd	25.69d	20.83a	19.23	6
R.Wolayta	11.11abc	14.58e	28.82cd	13.8bc	17.15	
mean	**10.52**	**18.94**	**29.01**	**18.31**	19.20	
CV%	25.64	11.26	7.94	16.90		
LSD	4.62	3.66	3.96	5.23		

*Grain yield figures followed by same letter(s) within a column are not significant at P≤ 0.05, whereas the numbers in brackets indicate the ranking of the variety by the farmers of the corresponding districts.
*Q =100 kg

1.2 Chickpea Participatory Variety Selection

Chickpea participatory variety selections were conducted in Halaba, Damot Woide & Kucha districts, and a researcher managed trial was carried out in Hawassa College of Agriculture research farm. Eight released varieties of chickpea (4 Kabuli and 4 Desi type) along with one local variety were used. The research sites have different agro-ecological characteristics (Table 3). A plot size of 9.36 m^2 (4 x 2.4 m) was used for each variety in a randomized complete block design with three replications.

Table 3. Some agro-ecologic characteristics of the sites for chickpea PVS trials during 2017

Location	Some agro-ecologic characteristics			District
	Altitude	Rainfall	Soil	
Hawassa	1760	900-1100	Sandy clay loam	Hawassa Zuria
Huletegna Choroko	18466	800-1200	Sandy loam	Halaba
Tora Wulisho	1960	1100-1500	Clay	Damot-woide
Wozete	1350	1100-1600	Vertisol	Kucha

NPS blended fertilizer at the rate of 100 kg ha^{-1} was applied at planting and insecticide (Karate) at the rate of 1 L in 200 L water per hectare was sprayed twice to control pod worm (African Boll Worm). The experiment at Hawassa received one supplemental watering using plastic hose at about pod formation stage.

Statistical analysis was conducted on the yield data collected by researchers from each district. Results showed that at Huletegna Choroko kebele of Halaba district, varieties were significantly different in grain yields. Varieties Dalota (2.8 t/ha), Teketay (2.6 t/ha), Ejerie (2.04 t/ha) and Habru (2.00 t/ha) produced better yield than the others (Fig 2); whereas farmers selected varieties Habru, Ejerie, Dalota and Teketay as first to fourth ranks in that order.

At Wezete kebele of Kucha district, the varieties differed significantly in yields (p=0.009). Teketay (2.46 t/ha), Dalota (2.43 t/ha), Ejeri (2.26 t/ha), Natoli (2.25t/ha) and Habru (2.23 t/ha) varieties produced better yields as compared to the other test varieties (Fig. 2), while variety Arerti (1.68 t/ha) and Shasho (1.78 t/ha) gave the least yields due to their late maturing characteristics, which exposed them to drought and bird damage. Farmers at Kucha selected variety Habru, Ejerie, Dalota and Natoli as first to fourth rank respectively. On the other hand, the female farmers preferred Desi type chickpea for stew preparation due to easy separation of their seed coats from cotyledons as compared to that of the Kabuli types.

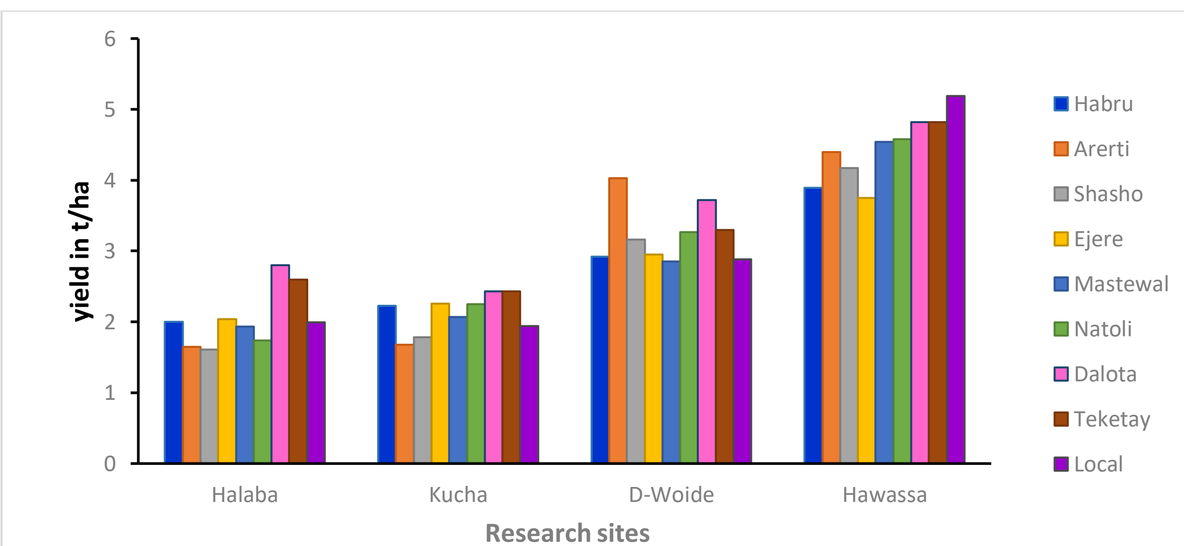

Figure 1. Performance of chickpea varieties at different agro-ecologies of project areas

At Sora Wolisho kebele in Damot-Woide district, Arerti (4.03 t/ha), Dalota (3.72 t/ha) and Teketay (3.03 t/ha) varieties gave significantly (p=0.0003) higher yield as compared to the other varieties (Fig. 2), whereas farmers selected Habru, Arerti, Ejerie and Dalota varieties in decreasing order from first to fourth rank. During the 2017/18 growing season, all the desi type varieties (Mastewal, Natoli, Dalota, Teketay) and the local variety were severely infested with Ascochyta blight just at flower initiation stage, which led to total damage (dried out) of the plants within two weeks in all replications. On the other hand, the kabuli varieties Arerti (3.54 t/ha), Habru(3 t/ha) and Ejeri (2.43 t/ha) were found to be completely tolerant, although variety Shasho (2.33 t/ha) was infected to a lesser extent.

The analysis of variance on grain yield at Hawassa showed statistically significant (p=0.037) differences between the test varieties. However, Local, Teketay, Dalota, Natoli, Mastewal and Arerti chickpea Varieties had similar performances with yield range of 4.4 – 5.19 t ha^{-1} (Fig. 2). The low yield obtained from Habru (3.89 t/ha) and Ejerie (3.75 t/ha) varieties could be attributed to low plant population caused by water logging problem.

1.2 Response of Haricot Bean (*Phaseouls vulgaris* L.) to Blended Fertilizers and Bio-fertilizer in Selected Districts of Southern Ethiopia

Girma Abera, Sheleme Beyene and Tussa Dedefo

The study was conducted to evaluate the role of some blended fertilizers and bio-fertilizer for haricot bean production in four districts (Halaba, Damota Gale and, Misrake Badewachew and Hawassa Zuria) of SNNPR state. Field experiments were conducted with new blended fertilizers along with rhizobia strain inoculation at Taba, Gacheno, Shone, Halaba and Hawassa using Hawassa Dume haricot bean variety as a test crop. The nutrient omission plots or control (0) was included in the treatments. The blended fertilizers and bio-fertilizers were evaluated in randomized complete block design (RCB) design with four replications. During 2016, six treatments (N, NP, NPK, NPKS, NPKSZn and NPK +bio-fertilizer) were tested at Taba, Gacheno, Shone, Halaba, while ten treatments (N, NP, NPK, NPKS, NPKSZn, N +bio-fertilizer, NP + bio-fertilizer, NPK+ bio-fertilizer, NPKS+ bio-fertilizer and NPKSZn+ bio-fertilizer) were tested at Hawassa. Similarly, during 2017 growing season, seven treatments (control, N, NP, NPK, NPKS, NPKSZn and NPK+bio-fertilizer) were tested at Taba, Gacheno, Shone and Halaba. The experiments were conducted on farmers' fields. A plot of 5 x 4 m size and spacing of 40 cm between rows and 10 cm between plants were maintained to carry out the experiment. All recommended agronomic packages and management practices were adhered as deemed necessary.

Analysis of variance revealed that there was no significant difference in grain yields at Taba, Shone-1 and Halaba sites in 2016. However, significant differences in gain yields were observed in Gacheno and Shone-2 (Table 5). Lower yields at Gacheno and Shone-2 locations were obtained in plots that received N fertilizer only, whereas the other four nutrient combinations performed in a similar fashion with only slight yield differences (Table 5). This finding implied that the soils of Gacheno and Shone-2 could be limited by most of essential nutrients (P, K, S and Zn) as they highly responded in high grain yield production. The soils of Gacheno and Shone-2 also positively responded to bio-fertilizer as compared to the plots that only received N fertilizer (Table 5). In general, the grain yield at Shone-1 was superior, while Halaba was poor as compared to other sites in 2016 (Table 4).

Haricot bean grain yield was significantly increased due to N and P application across three study sites out of the four locations at Hawassa in 2016 (Table 6). Similarly, pooled grain yield data over locations was significantly increased due to N and P application as compared to others. Potassium, sulfur and zinc application across the four locations of Hawassa areas did not bring any significant influence on grain yield

(Table 6). Bio-fertilizer also did not influence gain yield of haricot bean across study locations of Hawassa. The pooled data revealed that inoculation of commercial rhizobia (T7 to T10) resulted in reduction of grain yield, perhaps due to competition with indigenous rhizobia.

Analyses of variance revealed significant influence among chemical fertilizers in terms of grain yield of haricot bean across Taba, Gacheno and Shone locations (Table 6). The combined application of N and P increased grain yield by 15.8% at Taba and by 69.2% at Shone over control (Table 6). The combined N and P application increased grain yield by 29.4% at Taba and by 69.2% at Shone as compared to N alone application. Inoculation of commercial rhizobia (T7) significantly improved grain yield as compared to other treatments. The grain yield increase was 26.3%, 60.0% and 107.7% at Taba, Gacheno and Shone, respectively.

Table 4. Grain and total biological yield responses of common bean (Phaseolus vulgaris L.) to different blended fertilizers and bio-fertilizer applied during 2016 cropping season.

Treatmentcode	N:P:S:ZN in kg^{-1}	**Grain Yield (t ha^{-1})**				
		Locations				
		Taba	**Gacheno**	**Shone-1**	**Shone-2**	**Halaba**
T1	24:0:0:0:0	3.11	2.23b	4.01	2.50b	2.40
T2	24:20:0:0:0	3.17	2.43ab	4.50	3.31a	2.52
T3	24:20:60:0:0	3.48	2.74ab	3.62	3.34a	2.02
T4	24:20:60:8.5:0	3.16	2.70ab	4.43	3.10a	2.4
T5	24:20:60:8.5:1	3.40	2.59ab	3.86	3.26a	1.87
T6	24:20:60:0:0+ Biofert	3.04	2.81a	3.95	3.04a	2.07
LSD (5%)		NS	0.5	NS	0.32	NS
CV (%)		16.9	13.5	22.9	6.8	27.5
		Total Biological Yield (t ha^{-1})				
T1	24:0:0:0:0	5.27	3.80b	6.58	4.42b	3.91
T2	24:20:0:0:0	5.72	4.27ab	7.37	6.12a	4.76
T3	24:20:60:0:0	6.4	4.85a	5.92	6.20a	3.77
T4	24:20:60:8.5:0	5.61	4.85a	7.51	5.87a	4.61
T5	24:20:60:8.5:1	6.05	4.52ab	6.52	6.18a	3.92
T6	24:20:60:0:0+ Biofert	5.27	5.00a	6.74	5.78a	3.85
LSD (5%)		NS	0.7	NS	0.46	NS
CV (%)		16.7	11.3	22.6	5.35	26.3

Table 5. Grain and total biological yield responses of common bean (Phaseolus vulgaris L.) to different blended fertilizer and bio-fertilizer applied at Hawassa areas during 2016 cropping season.

Treat. code	**N:P:K:S:Zn in kg ha^{-1}**	**Grain Yield (t ha^{-1})**				
		Locations				
		Hawassa 1	Hawassa 2	Hawassa 3	Hawassa 4	Pooled
T1	24:0:0:0:0	1.7	1.1	1.7	1.6	1.53^{AB}
T2	24:20:0:0:0	2.1	1.5	1.5	2.3	1.85^{A}
T3	24:20:60:0:0	2.0	1.2	1.2	2.2	1.65AB
T4	24:20:60:8.5:0	1.9	1.1	1.2	1.9	1.53AB
T5	24:20:60:8.5:1	1.8	1.2	1.4	2.0	1.59AB
T6	24: 0:0:0:0 + Biofert.	1.7	1.2	1.4	2.0	1.58AB
T7	24:20:0:0:0+ Biofert.	1.8	1.3	1.3	1.5	1.48B
T8	24:20:60:0:0+ Biofert.	1.8	0.8	1.2	1.9	1.43B
T9	24:20:60:8.5:0+ Biofert.	1.7	1.3	1.2	1.8	1.50B
T10	24:20:60:8.5:1+ Biofert.	1.8	0.8	1.3	1.9	1.45B
CV (%)		7.7	18.9	12.2	12.7	8.10
		Total Biological Yield (t ha^{-1})				
	N:P:K:S:Zn in kg ha^{-1}	Hawassa 1	Hawassa 2	Hawassa 3	Hawassa 4	Pooled
T1	24:0:0:0:0	4.2	1.7	3.0	4.6	3.38AB
T2	24:20:0:0:0	4.7	2.3	3.2	4.7	3.73A
T3	24:20:60:0:0	4.4	1.3	2.1	4.1	3.05BCD
T4	24:20:60:8.5:0	4.3	1.4	2.1	4.3	2.64DE
T5	24:20:60:8.5:1	4.0	1.9	2.3	4.7	3.14ABC
T6	24: 0:0:0:0 + Biofert.	4.1	1.6	2.8	4.7	3.11BC
T7	24:20:0:0:0+ Biofert.	4.4	2.2	2.7	4.2	3.00CDE
T8	24:20:60:0:0+ Biofert.	3.7	1.2	1.8	4.1	2.48E
T9	24:20:60:8.5:0+ Biofert.	3.7	1.4	1.8	3.8	2.64DE
T10	24:20:60:8.5:1+ Biofert.	4.3	1.1	2.0	4.2	2.77E
CV (%)		7.8	25.8	18.4	7.3	

The total biological yield was significantly varied among the chemical and biological fertilizers tested (Table 6). Haricot bean total biological yield trends were similar to the grain yield trends (Tables 5, 6 and 7). Total biological yield was significantly increased due to combined N and P application across the four study locations at Hawassa (Table 6). The superior pooled total biological yield was recorded with NPK + bio-fertilizer application across the three locations of Taba, Gacheno and Shone followed by N and P supply. Similarly, pooled total biological yield data over locations was significantly increased due to N and P application as compared to other treatments. Potassium, sulfur and zinc application across the four locations of Hawassa areas did not bring any significant influence on total biological yield. Biofertilzer (inoculation) also did not influence total biological yield of haricot bean across study locations of Hawassa. Instead, the pooled data revealed that inoculation of commercial rhizobia resulted in reduction of total biological yield, perhaps due to competition with indigenous rhizobia. The lowest total biological yield was recorded in plots that received NPK and bio-fertilizer, followed by NPKSZN and bio-fertilizer (Table 6). Potassium and sulfur application had improved total biological yields at Gacheno and Shone but not at

Taba during 2017. The application of N, P, K, S and Zn resulted in total biological yield reduction as compared to others, perhaps due to an antagonistic relationship between P and Zn.

Table 6. Grain and total biological yield responses of common bean (Phaseolus vulgaris L.) to different blended fertilizer and bio-fertilizer applied at Walata areas during 2017 cropping season.

Treatment code	N:P:K:S:Zn in kg ha^{-1}	Grain Yield (t ha^{-1})			
		Locations			
		Taba	Gacheno	Shone-2	pooled
T1	0:0:0:0:0:0	1.9	1.5	1.3	**1.55bc**
T2	24:0:0:0:0	1.7	1.9	1.3	**1.63bc**
T3	24:20:0:0:0	2.2	1.5	2.2	2.01ab
T4	24:20:60:0:0	1.6	1.6	1.3	1.53c
T5	24:20:60:8.5:0	1.9	2.0	1.5	1.80bc
T6	24:20:60:8.5:1	1.7	1.5	1.3	1.40c
T7	24:20:60:0:0 + Biofert.	2.4	2.4	2.7	2.46a
CV (%)		16.9	13.5	22.9	6.8
		Total Biological Yield (t ha^{-1})			
T1	0:0:0:0:0:0	4.0	**2.9**	2.6	3.16bc
T2	24:0:0:0:0	4.0	**3.8**	2.9	3.55bc
T3	24:20:0:0:0	4.6	3.1	4.4	4.18ab
T4	24:20:60:0:0	3.6	**3.3**	3.0	3.30bc
T5	24:20:60:8.5:0	3.8	**4.1**	3.2	3.70c
T6	24:20:60:8.5:1	3.4	2.6	2.8	3.16c
T7	24:20:60:0:0 + Biofert.	4.8	**4.8**	5.5	5.00a
CV (%)		16.7	11.3	22.6	5.35

Generally, responses of haricot bean to blended and bio-fertilizers across locations was variable. N and P application positively improved grain yield of haricot bean at Gacheno, Shone- 2, Hawassa 1, Hawassa 2 and Hawassa 3 in southern Ethiopia. Potassium, sulfur and zinc application across the four locations of Hawassa areas did not bring any significant influence on total biological yield. Bio-fertilizer addition also improved grain and total biological yield of haricot bean across locations.

Annexes II

Table-1: Places and Number of People attending the gender training sessions (March - Sep 2017)

Project Woreda	Kebele	No. of people attended	Type of occasion for gathering	Remark
Halaba	Andegna-choroko	80	Water and soil conservation	
	Guba	150	Haricot bean seed distribution	
Damot Gale	Adde- Koysha	143	Soil and water conservation activity	At soil conservation activity closing day
	Shakisho Shone	70	Haricot bean seed distribution	
Shashogo	Tachigna Gimbicho	20	..	
	Bonasha washkota	25	..	
Damot-Woydie	Soro Koyo	150	Soil and water conservation activity	At soil conservation activity closing day
Hawassa-Zuria	Jara Galalcha	127	Haricot bean seed distribution	
	Labu Kormo	20	,,	
	Kajima	105	,,	
	Tenkaka	82	,,	
Boricha	Shello Belela	12	"	
	Sidamo Challa	8	"	
	Hanja Goro	300	Kebele Meeting	
M/Badwacho	Bulgita	173	Haricot bean seed distribution	
Sodo	Gogiti-3	26	Kebele Meeting	
Hulbareg	Demekie	1800	Soil and water conservation	Discussion at two watershed areas of the kebele
	Berhan Kitkita	20	,,	At closing day
Abeshgie	Borkana Seritie	325	,,	,,
	Tawula	70	,,	,,
	Lanchiena Amancho	500	,,	At the closing day, elementary school students attended the teaching
	Fenta	60	,,	At closing day
Daramallo	Menegna Abaya	50	Soil and water conservation activities	
	Hoya Degiza	56	Soil and water conservation activities	
Total	**24**	**3388**		

Table-2: Places and number of people attending the gender training sessions before March 2016

Project site/Woreda	Kebele	Estimated Number of people attended	Type of occasion for gathering	Remark
Boricha	Hanja Goro	100	Meeting	Kayo seed multiplication primary cooperative members meetings
Dorie Bafabano	Ambolo Tekaga	50	Meeting	Kebele arranged the meeting
Damot Woidie	Kindo Koyo	150	Soil and water conservation activity	Regular program carried out though out one month in every year.
	Kindo Koyo	192	Farmers' field day	One day during harvesting season
	Tora Wilisho	30	Soil and water conservation activity	Regular program carried out though out one month in every year.
Humbo	Abala Sipa	150	"	"
	Abala Fircho	100	"	"
Damot Gale	Taba	80	"	"
	Gachano	120	"	"
Hulaba	Churiko-2	215	"	"
Hulbarege	Bilwanja	250	"	"
	Wacho Bisho	450	"	"
	Worabet	60	"	"
	Eilros Dorie	950	"	"
Siltie	Seda Berango	700	"	"
	Seda Berango	321	Farmers' field day	One day in harvesting season
Kucha	Wuzetie	103	"	"
Sodo	Kiela Zuria	190	"	"
Total		**4111**		