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Research paper

Assessment of possibilities to establish model agricultural technology village in Southern Ethiopia

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The available technology demonstration approaches like farmers' training centers in the region are very narrow with lots of technology deficiency, less capacity, placed in inconvenience niches, and poor setup. Therefore, this study aimed to assess the possibilities to establish a model technology village in the Agricultural Growth Program implementing districts of the South Omo zone. The multi-stage sampling procedure was employed to select six sample kebeles. Data for the study were collected from 279 randomly selected households. Data collected were analyzed using descriptive statistics and a narrative approach. The major crop technologies identified were improved variety, inorganic fertilizer, seed rate, and spacing. Major livestock technologies identified were improved cattle, shoat, poultry, and forage types. Major natural resource management technologies identified were soil and water conservation, soil fertility management, and agroforestry practices. About 54%, 84.2%, and 57.7% of sample respondents from Semen Ari, Debub Ari, and Bena-Tsemay districts know the existing technology demonstration approaches such as farmers' training center, model farmer-based, and pre-extension demonstration approaches respectively. However, all types of agricultural technologies demonstration approaches and farmers' demands were not being taught, introduced, and demonstrated. Therefore, it can be concluded that establishing a model agricultural technology village on selected kebele based on farmers/agro pastoralists' demand for the crop, livestock, and natural resource management technologies could improve the productivity of smallholder farmers/agro-pastoralists.

Key words: *crop, livestock, natural resource management, technology village*

INTRODUCTION

As Ethiopia is a country following agriculture development lead industrialization (ADLI) policy where more than 85% of the total population are farmers living in rural parts of the country depending on agriculture. Agriculture accounts for 42% of GDP and nearly 80% of employment (ATA, 2017). Ethiopia is an exemplary and leading country in Africa in the production of some agricultural products. For instance, the country is leading in coffee production in Africa and 5th in the world. Ethiopia is again leading in Africa in live cattle production and 10th in the world although the cattle of

Ethiopia are low in quality. It is a home for Teff, Enset, and Durum wheat.

The growth of agriculture is a major driver of poverty reduction in rural Ethiopia. As a result, the government of Ethiopia has planned to increase agricultural productivity through the demonstration of agricultural technologies among other strategies. However, the current rate of technology adoption is low compared to the efforts of various governmental and non-governmental organizations working in agriculture. According to Shita et al. (2018), from the total crop area, on average nearly 50% of the land is covered by fertilizers and 20% by pesticides whereas the area covered by improved seed is less than 10% and irrigation is nearly 1% respectively. Even though the supply of improved agricultural technologies that help to increase agricultural production and productivity has increased over time, but still falls short of the target set to transform smallholder agriculture (MoFED, 2016). This is attributed to the approach being used for technology demonstration (Shita et al., 2018). In mid-April 2008, ECOSOC held Special Session on the Food Price Crisis. Combinations of short and long-term causes were identified for the crisis. To tackle this crisis, SG produced a Comprehensive Framework for Action (CFA) in July 2008 which encompasses Agricultural technology innovation and diffusion mechanism, particularly to smallholders, as a key to boosting yields' productivity sustainably (ECOSOC, 2015). Availability of area-specific technologies in farmers' vicinity can improve their production and productivity conditions and impact daily life. Means of such meaningful engagement with stakeholders by the prior understanding of social settings assist village institutions/society towards enhanced adoption of technologies. An Agricultural Technology village is a wider model area or village which is full of modern and improved agricultural technologies established to demonstrate and introduce the farming community with scientific, commercial, intense and simple, socialized, organized, cost-wise, and integrated agricultural technologies and production systems. It is a village where all types of agricultural technologies and cost-wise production systems are being taught, introduced, and demonstrated (PRC, 2015). Establishing a model technology village, where various improved agricultural technologies (crop, livestock, and natural resource management practices) can be demonstrated is believed to be very important. Knowing this importance, Southern Agricultural Research Institute commenced establishing a technology village around its centers with the help of the AGP program. The program is operating in 157 woredas of Ethiopia and 49 woredas in SNNPRS in line with the second growth and transformation program (GTP-II) of the country and the region. The research component of the AGP-II (component II) provides support to the agricultural research system to enhance technology supply to develop and promote agricultural technologies for inclusive and sustainable market-oriented smallholder agricultural growth in potential areas of the country in a manner that addresses the needs of women and youth.

The available farmers' training centers are very narrow with lots of technology deficiency, less capacity, placed in inconvenience niches, and poor setup. Though technology village is believed to improve production and productivity by supplying and demonstrating improved agricultural technologies, no evidence indicates trials made to establish technology village in southern Ethiopia. Therefore, it was found to be necessary to assess available possibilities that favor the establishment of a technology village before the work of the establishment, and this study is initiated to fill this gap.

MATERIALS AND METHODS

Description of study areas

The study was conducted in three AGP-II districts of the South Omo zone. The study areas were namely Debub Ari, Bena-Tsemay, and Semen Ari districts. The total population of the Debubi Ari district is 161,268 people. The number of farm households in the districts is 23317 HHs of which 21287 are male and 2030 are female household heads. Average family size and landholding (ha) per household are 6 and 0.25 respectively. The number of kebele in the district is 28 kebele. Whereas the total population of the Semen Ari district is 90,046 people and the number of farm households in the woreda is 30,182 HHs of which 28,743 are male-headed and 1,439 are female-headed households -. Average family size and landholding (ha) per household are 6 and 1.32 respectively. Number of kebele's in the woreda is 33 kebele. On the other hand, the total population of the Bena-Tsemay district is 151,129 people. The number of farm households in the district is 19632 HHs of which 10186 are male and 9446 are female household heads. Average family size and landholding (ha) per household are 8 and 1.21 respectively. Number of kebeles in the woreda is 32 kebele (SOZFEDD, 2018).

As per the traditional agroecology classification of the Debub Ari district, 37% is 'dega, 3 % is 'Wirch' and the rest 60% is 'woina dega'. The area is situated between 5.67 to 6.19-North latitude and 36.30 to 36.73 East longitude, Elevation ranges from 1200 m a.s.l to 3418 m. a.s.l. The average annual rainfall is 1450-mm. The mean annual temperature ranges from 10.1 – 27.5 oc and the mean annual temperature is 21 0c. On the other hand, the traditional agro-ecology classification Semen Ari district is woina dega (21%), kola (30%), and dega (39%), wurch (10%). The administrative seat of the district is Gelila Town located 602 km southwest of the national capital. The total land area of the district is 60,040 hectares. Average annual rainfall and temperature in the district vary between 400 mm and 2600 mm, and 11^{0}c and 22^{0}c respectively. The altitude varies from 900 meters to 3,200 meters above sea level. In terms of traditional agro-ecology classification, the Bena-Tsemay is Weynadega (19%), dry kola (78%), semi-arid (3%). The altitude of the district ranges between 500m.a.s.l and 1558 m.a.s.l. and the latitude of 5.01 – 5.73 North and longitude 36.38 – 37.07 East. The study area receives bi-modal rainfall distribution; the first peak, from mid-March to the end of April, is important for crop production, and the second peak, from mid-October to the beginning of November, is short and important only for pasture. The mean annual rain ranges between 200 and 578 mm and the mean annual temperature ranges between 17.6 c0 and 27.5 c0.

Sources and Methods of Data Collection

Both primary and secondary data were used to conduct this study. Primary data was collected from farmers, and agricultural experts working in the woreda. Secondary data was collected from different organizational reports and documents, and different published and unpublished sources. The data from primary data sources were collected using data collection instruments such as observation, pre-tested semi-structured questionnaires, focus group guide questions, and checklists. During observation, different types of available agricultural technologies, demonstration sites, available site for technology village establishment, previously used methods of demonstration, and the way the organizations approach beneficiaries to demonstrate was observed. A focus group guide question was set and data was collected from 8 members (3 model farmers, 3 youth, and 2 females) to have a clue about the overall scenario. Using checklists data were collected from agricultural experts working in the study woreda to have the overall outlook on the available technologies, the needs of beneficiaries, capacity and challenges of existing demonstration, previous experience in technology village establishment, and available convenient area/village for technology village establishment in the study district. The interview was employed to collect data from farmers using pre-tested semi-structured separate questionnaires.

Sample Size Determination and Sampling method

Regarding sample size, the sample size of farmers was determined using the formula of Yamane (1968). The computational process will be as follows.

$n=N/(1+Ne^2)$

Where n = the sample size, N= Total number of households in the study district, e= the error term, and 10% (0.1) was taken. Using the above formula total sample size was 279 households. The multi-stage sampling procedure was employed to select sample farm households. In the 1st stage, three AGP beneficiaries Woreda's were selected from the zone as a sample because only three were beneficiaries. In the 2nd stage, 3 kebele's were randomly selected from each sample woredas. In the 3rd stage, using the list of farmers in the sample Kebele's, the pre-determined size of representative households was randomly selected using a simple random sampling technique. In the 4th stage, the required sample size in each Kebele was determined proportionally to the number of households in each Kebele.

Method of Data Analysis

The analysis was conducted using descriptive statistics. Descriptive statistics such as mean, standard deviations, percentages, and frequency tables were employed to summarize the socio-economic and demographic characteristics related to sample respondents. A narrative approach was employed to describe details of the issue at hand.

RESULTS AND DISCUSSION

Major crop, livestock, and NRM technologies available in the study area

Major Crop Productions in the Study Areas

The major types of crops cultivated in Debub Ari are maize, sorghum, wheat and barley, common bean, onion, and tomato. As key informants reported that their livelihood mainly depends on crop production. Whereas in the Semen Ari district major crops cultivated are wheat, barley, faba bean, enset, and cassava. On the other hand, in the Bena-Tsemay district, the major type of crops cultivated include maize, sorghum, teff, finger millet, common bean, and groundnut. Thus, farmers/agro-pastoralists in the study districts produce crops for home consumption, income generation, and as a

Table 1. Quantity produced and land allocated for major crops

Districts	Major crops grown	Land allocated (ha) Mean	Quantity produced (qt) Mean	Productivity(qt/ha) Mean
Debub Ari	Maize	0.38	20.0	40.63
	Sorghum	0.20	3.70	18.5
	Common bean	0.13	3.33	15.62
	Wheat	0.41	5.28	12.9
	Barley	0.20	3.43	17.15
	Onion & Tomato	0.08	9.7	90.5
Semen Ari	Wheat	0.24	3.2	13.33
	Barley	0.22	3.7	16.81
	Faba bean	0.15	2.2	14.67
	Enset	0.15	Perennial	
	Fruits & Vegetables	0.42		
Benatsemay	Maize	0.41	17.61	38.95
	Sorghum	0.20	5.77	22.85
	Common bean	0.15	4.74	21.60
	Teff	0.30	3.73	12.43
	Finger millet	0.14	3.02	21.57
	Groundnut	0.19	2.95	15.53

Source: own survey, 2019

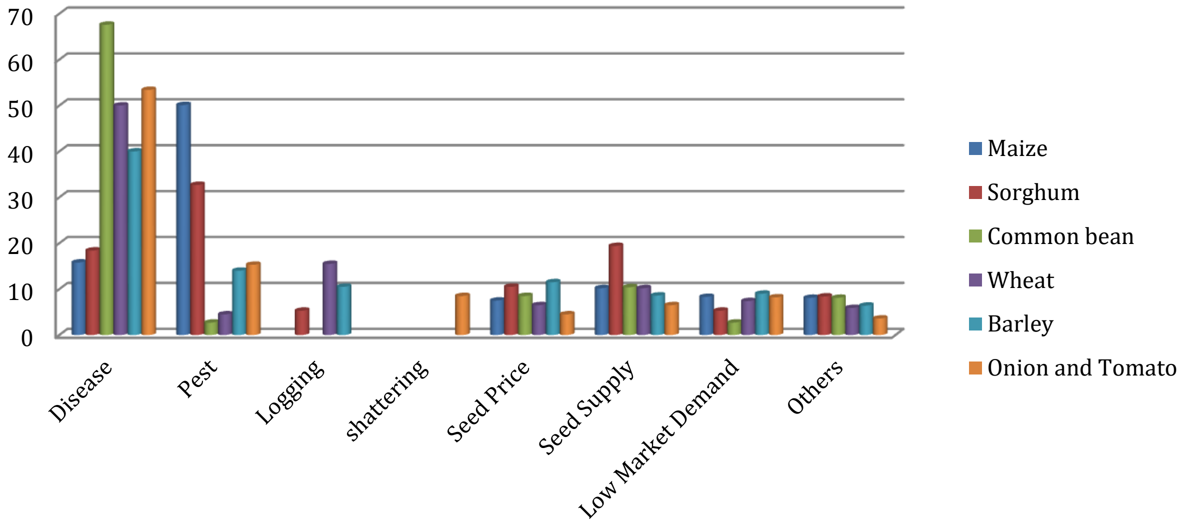

Figure 1. Main challenges of major crop production in Debub Ari district

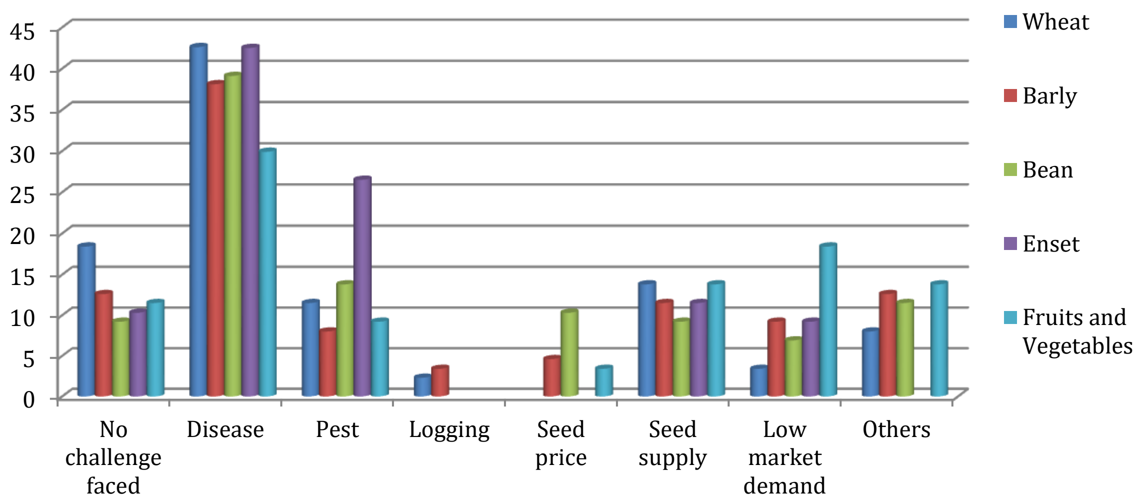

Figure 2. Main challenges of major crop production in Semen Ari district

Source: own survey,2019

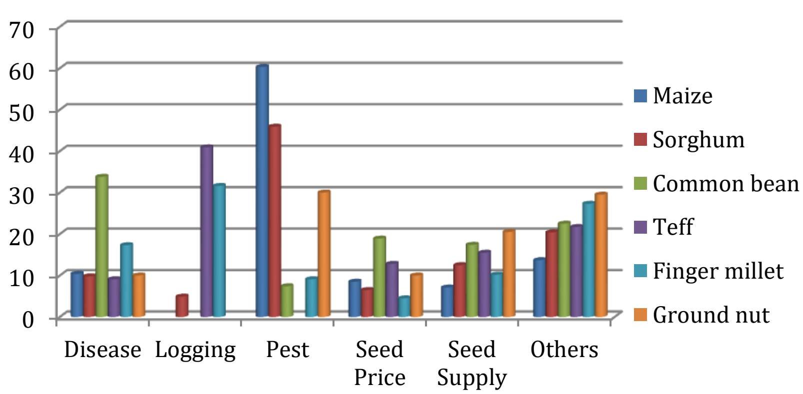

Figure 3. Main challenges of major crop production in the Bena-Tsemay district
Source: own survey, 2019

seed for further production. Table 1 below shows the land allocated for major crop production and productivity in Debub Ari, Semen Ari, and Bena-Tsemay districts. In the Debub Ari district maize, sorghum, wheat, and barley are the most important cereal crops which are grown in the study area with the mean land allocated of 0.38, 0.20, 0.41and 0.20 hectares and mean productivity per hectare of 40.63, 18.5,12.9 and 17.15 quintal respectively. The national average productivity of maize, sorghum, wheat, and barley per hectare is 39.44, 27.26, 27.36, and 21.57 quintals /hectare, and the regional average productivity of maize, sorghum, wheat, and barley per hectare is 38.06, 25.43, 26.6 and 19.04 quintals/hectare respectively (CSA, 2018). It is clear that maize productivity per hectare in the study area and national/regional averages is almost similar but others such as sorghum, wheat, and barley are below the national/ regional average productivity. Common bean is the major pulse crop produced in the study area in which the mean land allocated for it is 0.13 hectares and the mean productivity of 15.62 quintals. The mean land allocated for the production of onion and tomato in the study area is 0.08 hectares and the mean productivity of 90.5 quintals in the year 2011 E.C.

In the Semen Ari district, wheat and barley are the most important cereal crops which are grown in the study area with the mean land allocated of 0.24, 0.22 hectares, and mean productivity of 13.3 and 16.81 quintals respectively. Faba bean is the major pulse crop produced in the study area in which the mean land allocated for it is 0.15 hectares and the mean productivity of 14.67 quintals. Among the root crops, enset is one of the major crops produced in the study area, in which the mean land allocated for enset production is 0.15 hectares. Finally, the mean land allocated for the production of perennial crops particularly fruits and vegetables in the study area are 0.42 hectares in the year 2011E.C.

In the Bena-Tsemay district maize, sorghum, teff, and finger millet are the most important cereal crops which are grown in the study area with the mean land allocated of 0.41, 0.20, 0.30, and 0.14 hectares and mean productivity of 38.95, 22.85, 12.43 and 15.57 quintals respectively. Common bean is the major crop produced in the study area with mean land allocated of 0.15 hectares and a mean productivity of 21.60 quintals. Lastly, the mean land allocated for the groundnut in the study area is 0.19 hectares, and the mean productivity of 15.53 quintals in the year 2011 E.C.

Main challenges of major crop production

During the focus group discussion, and key informant interviews with district office experts, development agents, and farmers/agro-pastoralists the main challenge they raised for major crop production in the areas were diseases, pests, logging, seed price, seed supply, low market demand, climatic variability, drought, and erratic rainfall and others. Several insects/pests groups attack the flowers, fruits, stems, and roots of different crops. The major diseases and pests affecting maize, sorghum, teff, finger millet, wheat, and barley in the area fall armyworms, wag, and bacterial blight. For pulse crops, leaf miners and pod borers are the main diseases and pests. For those of fruit and vegetable crops fruit fly and root rot, and root and tuber crops mole rat and bacterial wilt are the main challenges of production. For those oil crops (Groundnut) root rot is the main challenge of production. As shown in figure 1 below, in the Debub Ari district, the disease is the main challenge for the production of crops in the study area that about 15.8% of maize producers, 18.4% of sorghum, 67.6% of common bean, 50% of wheat, 40% barley and 53.3% of onion and tomato producers responded their crops were affected by the disease in the production season 2011 E.C. Pest is another main challenge for major crops in the study area that about 50.1% of maize producers, 32.7% of sorghum, 2.7% of common bean, 4.5% of wheat, 14% barley and 15.2% of onion and tomato producers raised pest as the main challenge of major crop production. In the study area about 5.3% of sorghum, 15.5% of wheat, and 10.5% of barley producers reported that logging is a problem in cropping season 2011 E.C. In the study area shattering is also the main problem that occurs on onion and tomato, and 8.5% of respondents reported shattering is the main problem. About 7.5% of maize, 10.5% of sorghum, 8.5% of common bean, 6.5% of wheat, 11.5% of barley, and 4.5% of onion and tomato producers reported that seed price is the main challenge for production in the study area. In the study area about 5% of maize, 19.4% of sorghum, 10.4% of common bean, 10.2% of wheat, 8.6% of barley, and 6.5% of onion and tomato producers reported that seed supply is the main problem for production. About 3.5% of maize producers, 5.3% of sorghum producers, 2.7% of common bean producers, 7.4% of wheat producers, 9% of barley producers, and 8.2% of onion and tomato producers reported that low market demand is the major problem for the production of the crop in the area. Lastly, 8.1% of maize, 18.4% of sorghum, 8.1% of common bean, 5.9% of wheat, 6.4% of barley, and 3.6% of onion and tomato producers reported that the production of major crops was affected by climatic factors such as; drought and erratic rainfall in the study area.

As shown in figure 2 below, in the Semen Ari district about 18.4% of wheat producers, 16.2% of barley, 9.2% of faba bean, 10.3% of enset, and 11.5% of fruits and vegetables responded that no challenges were faced them during the production time of 2011 E.C. Disease is the main challenge for the production of crops in the study area that about 42.6% of wheat producers, 38.1% of barley, 39.1% of faba bean, 42.5% of enset and 29.9% of fruits and vegetable producers responded their crops were affected by the disease in the production season 2011 E.C. Pest is another the main challenge for major crops in the study area that about 11.5% of wheat producers, 8% of barley, 13.8% of faba bean, 26.5% of enset and 9.2% of fruits and vegetable producers raised pest as the main challenge of major crop production. On the other hand, logging sometimes happens on wheat and barley in the study area about 2.3% of wheat producers and 3.4% of barley producers reported that logging is happened on these two crops in cropping season 2011 E.C.

About 4.6% of barley, 10.3% of faba bean, 3.4% of vegetables and fruit producers reported that seed price is the main challenge for production in the study area. In the study area about 13.8% of wheat, 11.5% of barley, 9.2% of faba bean, 11.5% of enset, and 13.8% of fruit and vegetable producers reported that seed supply is the main problem for production. Low market demand is also one of the major problems for agricultural product marketing in the study area. About 3.4% of wheat producers, 9.25% of barley producers, 6.9% of faba bean producers, 9.2% of enset producers, and 18.4% of fruits and vegetable producers reported that low market demand is the major problem for the production of the crop in the area. Lastly, 8% of wheat, 12.6% of barley, 11.5% of faba bean, and 13.8% of fruit and vegetable producers reported that the production of major crops was affected by climatic factors such as; drought and erratic rainfall in the study area.

As shown in figure 3 below, in the Bena-Tsemay district disease is the main challenge for the production of crops in the study area that about 10.4% of maize producers, 9.8% of sorghum, 33.8% of common bean, 9.1% of teff, 17.3% finger millet and 10% of groundnut producers responded their crops were affected by the disease in the production season 2011 E.C. Pest is another the main challenge for major crops in the study area that about 60.3% of maize producers, 45.9% of sorghum, 7.4% of common bean, 9.2% of finger millet and 30% of groundnut producers raised pest as the main challenge of major crop production. On the other hand, logging sometimes happens on sorghum, teff, and finger millet in the study area about 4.9% of sorghum producers, 40.9% of teff, and 31.6% of finger millet producers reported that logging is happened on these three crops in cropping season 2011 E.C.

About 8.5% of maize, 6.5% of sorghum, 18.9% of common bean, 12.6% of teff, 4.5% of finger millet, and 10% of groundnut producers reported that seed price is the main challenge for production in the study area. In the study area about 7.1% of maize, 12.4% of sorghum, 17.4% of common bean, 15.6% of teff, 10.2% of finger millet, and 20.5% of groundnut producers reported that seed supply is the main problem for production. Lastly, 13.7% of maize, 20.4% of sorghum, 22.5% of common bean, 21.7% of teff, 27.3% of finger millet, and 29.5% of groundnut producers reported that the production of major crops was affected by climatic factors such as; climate variability, drought and erratic rainfall in the study area.

Major Livestock technology/Breeds in the study area

The major types of livestock found in the study areas of Debub Ari, Semen Ari, and Bena-Tsemay districts are cattle, shoat, poultry, and horse. Livestock is the second most important measurement of wealth for smallholder farmers in the Debub and Semen Ari districts. But in the Bena-Tsemay district, it is the first important measurement of wealth for agro-pastoralists. The local livestock breeds are dominant in the study areas but there are also some improved breeds such as Holstein Fersie, Jersey, and breeds. As reported in a group discussion with farmers/agro-pastoralists there is a difference in production and productivity and also in size between local and Holstein Fersia, Jersey, and Borana breeds. Due to the low milk productivity of local cow farmers in Debub and Semen Ari districts are interested to cross local with improved breeds. Crossed breeds gave better milk and butter than local ones. However, farmers/agro-pastoralists kept livestock for different purposes such as milk, meat, butter, hide, and skin. Selling of butter and live animals are common sources of income for their livelihood in the area. Milk is used for home consumption whereas other products like skin are being used for a bed.

Livestock feed in the Debub Ari district is mainly grazing on their farm (45%) and communal land (20%), and crop residues (35%). The water sources for their livestock are rivers and ponds near their home. There are haymaking practices from crop residues during crop harvesting season in Debub and Semen Ari districts. They provide mostly crop residues for milking cows and ploughing oxen. There is a practice of planting improved forage such as elephant grass, pigeon pea, Rhodes, panicum, and desho grass. The district office, Jinka agricultural research center, and NGOs supplied chicken breeds specifically, koek-koek, saso, and leghorn to the farmers/agro-pastoralists but they are susceptible to disease and died for most farmers/agro-pastoralists. Local hens are dominant and more resistant to disease than

Table 2. Livestock technology available in the study area

Districts		Debub Ari		Semen Ari		Bena-Tsemay	
Livestock technology available	Type of livestock technology	Number owned	Average	Number owned	Average	Number owned	Average
Local	Cow	190	3	160	2	271	6
	Ox	130	2	35	0.4	180	3
	Heifer	39	2	18	0.2	50	2
	Sheep	141	4	453	5	39	2
	Poultry/hens	174	5	68	1	210	6
	Goat	44	3	55	1	337	8
	Honey bee	21	4	2	0.2	12	0.7
Improved	Cow	29	1	20	0.2	6	0.4
	Ox	5	0.2	4	0.1	3	0.3
	Poultry/hens	183	4	54	1	190	6
	Sheep	9	0.3	5	0.1	-	-
	Goat	6	0.2	-	-	6	0.7
	Honey beehive	-	-	-	-	2	0.1

Source: own survey, 2019

improved. The purpose of rearing hens is to get income, especially in selling eggs. In this area, females have a decisive role in the production and marketing of products. As shown in Table 2 below the average local livestock holding (cow, ox, heifer, sheep, hen, goat, and honey bee) of sample respondents in the study are 3, 2, 2, 4, 5, 3, and 4 respectively. Whereas average improved livestock/breed holding (cow, ox, hen, sheep, and goat) of sample farmers in the study area are 1, 0.2, 4, 0.3, and 0.2 respectively. Improved chicken is more introduced than other livestock. In general indigenous livestock, types are dominant in the study area. Chicken is the largest class of livestock owned by sample households followed by cows. This could be due to the type of agroecology of the study area favoring chicken and cows over other livestock. The majority of sample respondents have a local honeybee colony in the Debub Ari district. In the Semen Ari district, the average local livestock holding (cow, ox, heifer, sheep, hen, horse, and honey bee) of sample respondents in the study are 2, 0.4, 0.2, 5, 1, 1, and 0.2 respectively. Whereas average improved livestock/breed holding (cow, ox, sheep, and hen) of sample farmers in the study area are 0.2, 0.1, 0.1, and 0.1 respectively. Improved hens are more introduced than other livestock. In general indigenous livestock, types are dominant in the study area. Sheep are the largest class of livestock owned by sample households followed by cattle. This could be due to the type of agroecology of the study area favoring sheep over other livestock. Horses provide transport of farm input. The majority of sample respondents have local honeybee colonies. In the Bena-Tsemay district, the average livestock holding (cow, ox, heifer, sheep, hen, goat, and honey bee) of sample respondents in the study are 6, 3, 2, 2, 6, 8, and 0.7 respectively. Whereas average improved livestock/breed holding (cow, ox, Boar goat, hens, and honey bee) of sample farmers in the study area are 0.4, 0.3, 0.7, 6, and 0.1 respectively. Improved hens are more introduced than other livestock. In general indigenous livestock, types are dominant in the study area. Goat is the largest class of livestock owned by sample households followed by poultry. This could be due to the type of agroecology of the study area favoring goats over other livestock. Some samples of respondents have a modern beehive and majorities have local honeybee colonies.

Main challenges of livestock technology

As discussion made with key informants, the main challenges for livestock production and management in the study area are diseases, shortage of feeds, shortage of grazing land due to expansion of agricultural land and fragmentation of land for children, and marketing problems. The death of livestock is due to a lack of/less veterinary services and less support from extension agents on timely vaccination. And also feed was a great challenge for improved cows (Holstein, Jersey, and Borana), Boar goat, and Bonga sheep because they need a high amount of forage. As shown in figure 4 below, about 82%, 17%, and 1% of respondents said the main challenges for livestock production and management are disease, feed, and shortage of land respectively in the Debub Ari district. And also about 43%, 24%, and 14% of sample respondents said the main challenges for livestock production and management are disease, feed, market problems, and respectively in the Semen Ari district but 19% of respondents said there was no problem for livestock production. Moreover, about 79%, 18%, and 3% of respondents said the main challenges for livestock production and management are disease; feed shortage during drought season, and price fluctuation respectively in the Bena-Tsemay district during survey time. As sample respondents revealed, chickens from extension are very sensitive to disease/bacterial, viral, and parasites and die daily if they are not continuously provided feed and vaccination.

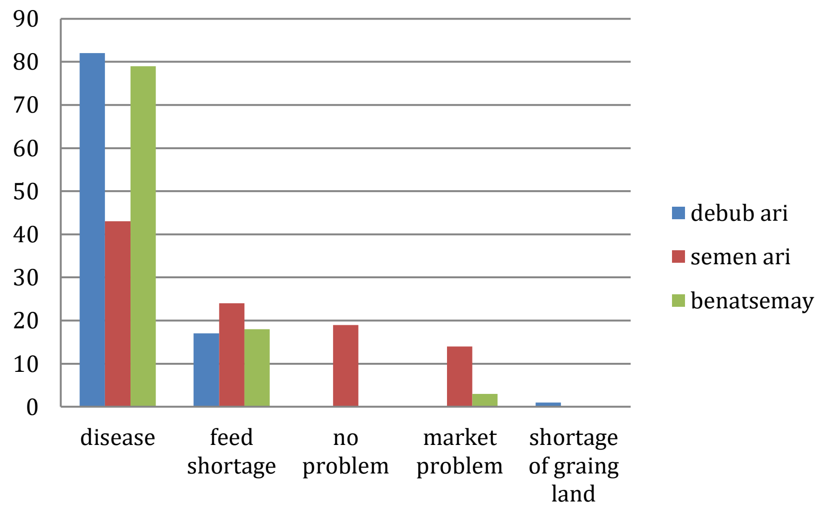

Figure 4. Main challenges of livestock production and management

Source: own survey result, 2019

Major natural resource management technologies practiced Soil and water conservation practices

In the districts, there is a problem of land degradation due to inappropriate land-use systems, erosion, and deforestation. As a result, the land of farmers/agro-pastoralists was susceptible to soil erosion and which causes the loss of upper fertile soil. Community participation in soil and water conservation structures is increasing from time to time and it has greater importance in protecting losses of soil and water. Some individual farmers/ agro-pastoralists planted desho and elephant grass to conserve soil and to use it as feed for livestock.

In the Debub Ari district, about 45.3% of respondents revealed that they practice physical SWC on farmland whereas about 54.7% do not practice but they participate in watershed management. Thus, the physical SWC structures practiced are soil bund, stone bund, half-moon, and fanyajuu. As shown in Table 4 below, about 74.4% and 20.9% of sample respondents practice soil bund and stone bund on individual farmland respectively. In the Semen Ari district, different SWC practices have been carried out at individual or community levels. About 73.6% of respondents revealed that they practice physical SWC on their farm whereas about 26.4% were not practicing physical SWC on communal land. Physical SWC practices widely implemented on farmland in the area are soil and stone band and half-moon. About 81.3% and 17.2% of sample respondents practice soil bund and stone bund on the physical SWC structures practiced are soil and stone bund. About 59.5% and 40.5% of sample respondents practice soil and stone bund on individual farmland respectively.

Soil fertility enhancement methods

As revealed in a focus group discussion with experts and farmers/agro-pastoralists, the soil fertility status in the study area decreased from time to time due to the repeated cultivation of land followed by population increment. Different introduced soil fertility improvement technologies or inputs are supplied to farmers by the district office. Of those, the most common currently in use are NPSB, NPS, NPSZN, and Urea, MOP (potassium chloride) fertilizer is used in highland parts of the districts mainly in Debub and Semen Ari. Recently the trend of using these fertilizers increased but the price of it is highly increasing.

About 49.5%, 22.1%, 17.9%, 6.3% and 4.2% of sample respondents use inorganic fertilizer, crop rotation, intercropping, fallowing and compost & FYM respectively to enhance soil fertility in Debub Ari district whereas, in Semen Ari district sample respondents use crop rotation (44.8%),

Table 3. Physical SWC practice in the area

Attributes of SWC		Districts					
		Debub Ari		Semen Ari		Bena-Tsemay	
		Frequency	%	Frequency	%	Frequency	%
The practice of physical SWC	Yes	43	45.3	64	73.6	18	18.6
	No	52	54.7	23	26.4	79	81.4
Types of physical SWC	Soil bund	32	74.4	52	81.3	47	59.5
	Stone bund	9	20.9	11	17.2	32	40.5

Source: own survey, 2019

Table 4. Soil fertility enhancement in the area

Soil fertility enhancement in the area	Districts					
	Debub Ari		Semen Ari		Bena-Tsemay	
	Frequency	%	Frequency	%	Frequency	%
Intercropping	17	17.9	1	1.1	53	54.6
Inorganic fertilizer application	47	49.5	10	11.5	35	36.1
Crop rotation	21	22.1	39	44.8	1	1
Fallowing	6	6.3	25	28.7	5	5.2
Compost and FYM application	4	4.2	11	12.6	2	2.1

Source: own survey, 2019

Table 4. Practice of tree planting & management

The practice of tree planting & management		Districts					
		Debub Ari		Semen Ari		Bena-Tsemay	
		Frequency	%	Frequency	%	Frequency	%
Reforestation		73	76.8	50	57.5	44	45.2
Afforestation		16	16.8	37	42.5	14	14.4
Area closure		6	6.3	-	-	39	40.2
Nursery site	Yes	41	43.2	22	18	18	18.6
	No	54	56.8	65	79	79	81.4

Source: own survey, 2019

their farmland respectively. On the other hand, in the Bena-Tsemay district, about 18.6% of respondents reported that they practice physical SWC on their farmland whereas about 81.4% do not but practice physical SWC (Table 3)on degraded communal lands and agro-pastoralists training centers. Thus, fallowing (28.7%), compost and FYM(12.6%), intercropping(1.1%), inorganic fertilizers (11.5%) to enhance soil fertility. As sample respondents revealed farmers intercrop maize with common bean, maize with sorghum, etc. to enhance soil fertility. Moreover, they use inorganic fertilizers such as NPSB and urea by purchasing from the extension. On the other hand, in the Bena-Tsemay district about 54.6%, 36.1%, 1%, 5.2%, and 2.1% of sample respondents use intercropping, inorganic fertilizer, crop rotation, fallowing, compost & FYM, and respectively to enhance soil fertility.

Irrigation practices

In study districts, traditionally, farmers/agro-pastoralists practice irrigation, and their primary sources of water are rivers and springs. The method of application to this indigenous irrigation scheme in the areas was conventional small furrow irrigation. By using this irrigation practice farmers/agro-pastoralists commonly produce horticultural crops such as onion, tomato, cabbage, etc. There are no modern irrigation practices in the study area/districts.

Forest resource management, Agroforestry, and Tree planting practices .

As per key informants' interviews and discussions with the district office, in the past decades there was a very dense forest in the districts but now a day it is highly decreasing due to shifting cultivation or deforestation of forest land for agricultural purposes. This year as the government agenda reforestation of degraded lands and afforestation was done on communal lands. But most seedlings were purchased from private nursery sites and nursery establishment in the district itself is very weak. About 76.8%, 57.5%, and 45.2% of sample respondents in Debub Ari, Semen Ari, and Bena-Tsemay districts revealed that there was high community mobilization to reforest the previously degraded areas respectively. And also about 16.8 %, 42.5%, and 14.4% of respondents in Debub Ari, Semen Ari, and Bena-Tsemay districts have participated in afforestation of watershed and mountainous areas whereas 6.3% and 40.2% of respondents in Debub Ari and Bena-Tsemay districts participated in area closure respectively. But most seedlings were purchased from private nursery sites and nursery establishment in the district itself is weak because currently there is no model nursery site. About 56.8%, 79%, and 81.4% of sample respondents in Debub Ari, Semen Ari, and Bena-Tsemay districts revealed that there was no site in their area, and 43.2%, 18%, and 18.6% of respondents said that there is nursery site but not equipped with materials.

Table 5. Crop technology demand of selected kebele's for technology village establishment

	Crop technology	Type of crop variety in the order of importance	Reasons for preferring this technology	The rank of crop technology
Alga	Maize	BH140	High yielding and Consumption	1
	Sorghum	Lalo, Dano, and Dekeba	Consumption, High yield, and high price	4
	Common bean	Hawassa dume and Nasir	Consumption, high price, and High yield	2
	Cassava	Kule and Kello	Consumption, High yield, and Source of income	3
	Sweet Potato	Improve Variety	Consumption, high yield, and Source of income	6
	Onion and Tomato	Improve Variety	High yielding and Source of income	5
Goldia	Maize	Melkassa 2, Melkassa 4 and BH 140	Consumption, high yield, income generation, and early maturity	1
	Sorghum	Dekeba and Dano	Consumption and High yield early maturity	2
	Common bean	Nasir and Hawassa dume	Consumption, income generation, and drought resistance	3
	Teff	Kuncho, Asnakech, and Boset	High yield, income generation, and Suitable for the agro-ecology	4
	Finger millet	Improved Variety	Income generation, high yield, and suitable for the agro-ecology	5

Source: own survey, 2019

Table 6. Practice of tree planting & management

The practice of tree planting & management		Districts					
		Debub Ari		Semen Ari		Bena-Tsemay	
		Frequency	%	Frequency	%	Frequency	%
Reforestation		73	76.8	50	57.5	44	45.2
Afforestation		16	16.8	37	42.5	14	14.4
Area closure		6	6.3	-	-	39	40.2
Nursery site	Yes	41	43.2	22	18	18	18.6
	No	54	56.8	65	79	79	81.4

Source: own survey, 2019

Technology demand of farmers/agro-pastoralists in selected woreda's

Crop technology demand of farmers/agro-pastoralists in the study area

During the focus group discussion, district experts and kebele agents reported a shortfall in seed supply which doesn't meet the demand of farmers, and also the long channel of supply of improved variety that comes through the regional, zonal, and district extension. So it is better to assess farmers/agro-pastoralists demand for improved crop variety to be supplied in the coming season are based entirely on official forecasts that are developed at the local (kebele) level and then transmitted through official channels to zonal and regional levels. Accordingly, farmers/agro pastoralists' demand for improved crop technology in Debub Ari (Alga kebele) and Bena-Tsemay (Goldia) districts is presented in table 8 below.

Livestock Technology demand of farmers/agro-pastoralists in the study area

Sample respondents in the study area indicated different reasons for preferring different types of livestock technology-. The demand of farmers/agro-pastoralists for local or improved livestock technology/breed varies with a relative advantage of livestock technology/breed type in terms of disease-resistant and productivity. Sample respondents highly demanded improved livestock breeds than locals in the study areas. Moreover, their preference is directly related to the importance they have in their livelihood improvement.

Natural resource management technology demand of farmers/agro-pastoralists

Sample respondents in the study area indicated different reasons for preferring different types of natural resource management technologies. Farmer's/agro pastoralist's natural resource technology demand in the study area is shown below in table 10.

Farmer's/agro pastoralists' perception of the existing technology demonstration approaches

For the appropriate implementation of any new technology, farmers/agro-pastoralists/pastoralists need to be conscious and responsive to effectively use the given technology. In the study area, the farmers/agro-pastoralists/pastoralists' perceptions about the importance of the existing technology demonstration approach were somehow good and information through extension agents and some NGOs was also available. As can be seen from Table 11 below about 54%, 84.2% and 57.7% of sample respondents from districts know the existing technology demonstration approaches respectively. The existing technology demonstration approaches which are commonly known by respondents in the districts are FTC/APTC, a Model farmer-based, PED, and FREG demonstration approaches. Sample respondents in the Semen Ari district prefer FTC and pre-scaling up approaches of demonstration because it is simple to share experience and knowledge from farmers, experts and others support each other at the same time whereas respondents from Debub Ari and Bena-Tsemay districts preferred FTC/APTC, Model farmer-based, PED and pre-scaling up approaches because all they are important to transform farmers/ agro-pastoralists gradually. About 91.4%, 98.8%, 75% of sample respondents who know the existing technology demonstration approach are involved in technology demonstration approaches in Semen Ari, Debub Ari, and Bena-Tsemay districts respectively.

Convenient area to technology village establishment

The study assessed three kebele of each AGP-II district in the study area. One convenient kebele was selected from each

Table 7. NRM technology demand of selected kebele's for technology village establishment

	NRM technologies	NRM practices in order of importance	The reasoning for this technology	Rank NRM practices
Goldia	SFM	NPS and urea, intercropping, and crop rotation	Increase soil fertility & increase productivity	2
	SWC	Soil and stone bund, pigeon pea, and elephant grass planting	Decrease soil and water loss, increase productivity, and used as forage	4
	Agroforestry	Mixed farming of crops with wanza, grevillea, moringa, pigeon pea, and cowpea	Manage land efficiently, used as forage, shade and increase soil fertility, and high-income source	1
	Irrigation	Watering of crops from river and spring (traditional) and water harvesting	Reduce the dependency on rainfall, two-season harvest, and increase income	3
Alga	SFM	NPSB, urea, intercropping	Increase soil fertility & increase productivity	1
	SWC	Soil bund, watershed development, alfalfa, desho, and elephant grass planting	Decrease soil and water loss, increase productivity, and used as forage	3
	Agroforestry	Mixed farming of crops with wanza, grevillea moringa, banana, coffee, enset, and mango	Manage land efficiently, used as forage, shade and increase soil fertility, and high-income source	2
	Irrigation	Traditionally by hand watering from rivers	Reduce the dependency on rainfall, two-season harvest, and increase income	4

district for technology village establishment

CONCLUSION

The major types of crops cultivated in the study are maize, sorghum, common bean, wheat, barley, faba bean, enset, cassava, finger millet, and groundnut. The major types of livestock technologies available in the study area are cattle, shoat, poultry, and horse. Livestock is the second most important measurement of wealth for smallholder farmers in the Debub and Semen Ari districts. But in the Bena-Tsemay district, it is the first important measurement of wealth for agro-pastoralists. Major natural resource management practices available are soil and water conservation practice, soil fertility enhancement, and agroforestry practices. The demand of farmers/agro-pastoralists/pastoralists for improved technology and perceptions about the importance of the existing technology demonstration approach was somehow good and also information was addressed through extension agents and some NGOs. However, all types of agricultural technologies and farmers' demands were not being taught, introduced, and demonstrated. As result, it can be concluded that establishing a model agricultural technology village on selected kebele based on farmers/agro pastoralists' demand for the crop, livestock, and NRM technologies could improve the productivity of smallholder farmers/agro-pastoralists.

AUTHOR CONTRIBUTIONS

The authors developed concept, initiated the research proposal, conducted the research in the field, reviewed and edited the research proposal and manuscript; collected data, analysis and writing the full manuscript. All are equally contributed.

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COMPETING INTERESTS

The authors have no conflict of interests.

ETHICS APPROVAL

Not applicable

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