AGRICULTURAL PRODUCTION SYSTEMS IN AGP-II DISTRICTS IN THE CENTRAL HIGHLANDS OF ETHIOPIA

Agajie Tesfaye
Aklilu Nigussie
Diriba Hunde
Fekede Feyissa
Getachew Agegnehu
Getachew Ayana
Mussa Jarso
Worku Atlabachew
Chilot Yirga
Diriba Geleti

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Ethiopian Institute of Agricultural Research

AGRICULTURAL GROWTH PROGRAM

AGRICULTURAL PRODUCTION SYSTEMS

IN

AGP-II DISTRICTS

IN THE

CENTRAL HIGHLANDS OF ETHIOPIA

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Website: http://www.eiar.gov.et
Tel: +251-11-6462633
Fax: +251-11-6461294
P.O.Box: 2003
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Executive Summary

Agricultural Growth Program (AGP) is a multifaceted investment program supporting agricultural productivity and commercialization focusing on high agricultural potential areas. It is one of the key investment mechanisms for development partners and the government. Following completion of the first AGP (AGP-I), the second AGP (AGP-II) was designed on the basis of the lessons and best practices drawn from AGP-I to improve implementation and maximize the overall impact of the program. The overall objective of AGP-II is to increase agricultural productivity and commercialization of targeted smallholder farmers and contribute to dietary diversity and consumption at household level.

The study was conducted in samples of AGP-II districts from Oromia Region. Accordingly, Ambo district was selected from West Shewa Zone while Grar Jarso was identified to be representative of North Shewa Zone. Woliso district was also selected as one of the samples from southwest Shewa Zone. The farming community, zonal and district agriculture professionals, agricultural researchers and NGOs were the major sources of information for the study. Qualitative participatory approaches including focus group discussions, key informant interviews, proportional piling techniques, matrix rankings, historical analysis, and other tools were used to collect the required information and address the objectives. Exhaustive desk review was also made as a supplementary approach to capture sets of information from print and electronic media. This report, therefore, presents the findings of the study and proposes options of recommendations that help address the identified constraints.

Major Findings

Socio-economic circumstances and challenges

According to the perception of the community, about 50% of the households were estimated to fall in the resource poor wealth category while it is 40% for medium and 10% for well-to-do (wealthy) households. Even though agricultural extension service is believed to be accessible to all wealth categories, medium and poor wealth category households, which account for about 90% of the population have not adequately utilized extension services as per the recommendations on account of resource limitation to afford technological packages.

The study has also identified options of rural credit sources for the farmers, including Micro-finance and other institutions, such as *WALQO, WASSASA, ESHET, WISDOM, VISION FUND, and BUSA-GU NOFA.* However, less than 10% of the farming households were reported to be beneficiaries of rural credit services, mainly because

of unfavorable and cumbersome bureaucratic processes to undergo before getting the credit. The amount of credit available for a household is also perceived to be inadequate to purchase the required agricultural technologies and inputs. High default rate and unsatisfactory loan recovery has prompted the financial institutions to become wary of granting loan.

Even though extension service is being provided in various approaches including establishment of farmer training centers (FTCs), more than 50% of them were reported to be non-functional. The functional ones were not even operating in their full capacities. The major reasons associated with FTCs were identified to be inadequate operational budget allocation to run FTCs and unavailability of experimental plots of their own.

Extension service was observed to involve gender disparity leaving 20% of female household heads at a disadvantage condition while more than 60% of men have access to extension services and 15% for youth. In the perspective of gender roles within a family, it has also been estimated that women and youth operate on more than 70% of livestock related activities, while this proportion is 40% in crop production. Coupled with domestic chores, women appeared to be over-burdened as they are usually engaged at work for 15 hours a day while it is 11 hours for men during peak cropping seasons. Even during slack periods, work burden of women does not decrease significantly as it does for men. Consequent to this, the chance of involvement of women in development initiatives and extension services, such as trainings, experience sharing, and other events has appeared to be minimal. While there is some improvement over time for shared role, decision-making power is vested in men in male-headed households. Involvement of youth is also increasing over time in various farming operations even though unemployment status has become acute problem in rural areas especially for undergraduates.

The major socio-economic problems identified include limited access to agricultural technologies, inadequate access to credit services; unavailability of special-purpose women-based cooperatives; increasing unemployment rate of rural youth; high work-load on women; ineffective mobile network coverage; inadequate transportation services; and limited utilization status of agricultural mechanization tools and machineries.

Practices and challenges in crop production

The highland agro-ecology featured dominance of traditional and subsistence type of crop production. The major crops grown are Tef, Wheat, Barley, Maize, Sorghum, Faba Bean, Field Pea, Chickpea, Lentil, Grass Pea, Noug, Linseed, Gomenzer,

Tomato, Onion, Garlic, Cabbage, Potato, Vetch, and Oats. Even though farmers largely depend on traditional endemic crops, there are also some recently introduced crops to the farming systems, such as Quality Protein Maize (QPM) and Highland Maize, Malt Barley, Kabuli Chickpea, Triticale and Oats. Improved varieties of various other crops have also been introduced. For instance, improved varieties of maize, wheat, and tef are reported to be under production by most of the farmers. However, limited availability of seeds for improved varieties of Barley, Faba Bean, Field Pea, Chickpea, and other crops has been a constraint to most of the farming community.

Even though, highly productive and disease tolerant varieties are largely demanded by the farmers, shortage of quality seed of improved varieties has appeared to be acute problem for technology dissemination. The problem is especially severe for female headed households who still have limited access to agricultural technologies. Sudden sensitivity of Yellow Rust is also driving various improved wheat varieties out of production. Apart from existing pests and diseases which are commonly known in the farming systems, there are also new ones which have emerged to be challenges in crop production. For instance, the new Faba Bean Gall Disease—locally named as *qormid*— has appeared to be seriously threatening Faba Bean to get out of production unless timely corrective measure is in place. Fall armyworm has also appeared to be a new threat to crop production. Field pea production has also been risked due to perpetuation of severe aphid infestation, consequent to which large numbers of farmers have started to quit from production of field pea.

Even though, use of inorganic fertilizer is a common practice for more than 90% of the farmers, the use of the newly introduced bio-fertilizers on legumes such as faba bean and chickpea is increasing over time. The issue on fertilizer use is not just application, but the quantity applied per unit area, which is often below the recommended rate. Because of this, many of the farmers are compromising substantial amount of production.

Chemical use is also becoming a common practice among the farmers on insects, diseases, and weeds. The problem, however, was associated with poor quality of chemicals and limited awareness of the farmers on the safety and handling mechanisms of the chemicals. For instance, most of them do not use safety devises while spraying and keep chemicals at home alongside of consumables, such as cooking oil and foodstuff. Because of this, they are experiencing health problems including loss of human life. New grass weeds on croplands have also appeared to be threats, especially for cereal production, because these weeds can neither be controlled by existing chemicals nor pulled out by hand.

Climate change is also threatening crop production in all sample districts. For instance, farmers' crop production using short rainy season (Belg season) is declining over time and it has even been abandoned in some of the locations because of poor rainfall distribution. Even though improved crop varieties have the potentials to provide high yield, about 50% of the productivity is compromised by climate change. To minimize the effect of climate change, farmers are employing options of adaptation mechanisms, such as rainwater harvesting, the use of short season crop varieties and conservation agriculture, and others. However, the proportion of farmers practicing these mechanisms was reported to be minimal due to the fact that they are fragile to climate change effects, and their resilience capacity is very poor.

The major problems hindering crop production and productivity include wheat rust and foot rot; onion rust, garlic root rot, maize virus MLND, and Faba Bean Gall. Among the insect pests, tef shoot fly; Field Pea and Grass Pea Bollworm and Aphids; and emergence of fall armyworm were identified to be threats to crop production. Climate change related problems, such as shortage and erratic distribution of rainfall were prevalent. Limited seed availability, inadequate dissemination, and limited use of the already available improved crop varieties were reported to be challenges to crop production.

Practices and challenges in livestock production

Livestock production contributes 50–70% of the livelihoods of the farming community as sources of income, food, fuel, draught power, manure and as indicators of wealth and prestige. Even though offices of agriculture, agricultural research centers, and NGOs have been making utmost efforts in disseminating crossbred cows and associated dairy technologies, more than 98% of the cattle populations especially in West and South West Shewa Zone are still indigenous breeds, indicating that dairy production technologies are not yet accessible to smallholder farmers. The major factor behind this trend is limited availability of crossbred heifers/cows. When available, the price of a crossbred heifer/cow is quite unaffordable to smallholder farmers with estimated market value of more than ETB 40,000 per crossbred cow.

In spite of the high demand for crossbred cows, there is no formal crossbred heifer rearing centers in the country except a few private heifers rearing enterprises that are not able to meet the growing demand over time. Those farmers who are engaged in dairy farming are not adopting recommended dairy management practices, because of which they are not exploiting the maximum productivity potentials of crossbred cows. Limited knowledge and skills coupled with inadequate economic capacity to afford operational cost are the major factors responsible for poor dairy management.

Keeping large numbers of unproductive animals on small size of grazing lands is also compromising livestock productivity. For instance, the recommended number of livestock to be kept on a hectare of land is 3 tropical livestock unit (TLU) while farmers actually kept more than five folds of animals (17 TLU) per hectare of land. Such overstocking of livestock per unit area not only compromises productivity but also degrades soil fertility and threatens biodiversity. Pasture land productivity is also becoming severely affected producing not more than one tone of dry matter (DM) from a hectare of land, about eight folds less than the productivity that can be obtained from well managed pasture land, which is 8 t DM/ha.

The study has also figured out that pasture production could be a competitive business rewarding the farmers with substantial income. For instance, from a hectare of land that can produce about 8 ton of DM, farmers can obtain more than ETB 37,000 gross income from sales of hay bales with minimal operational cost. On the other hand, production and sale of many of the cereals and other crops may not provide as high income as pasture because of their high production cost. Besides, green oat production as livestock feed has appeared to be the most paying enterprise with an estimated gross income of more than ETB 100, 000 per hectare of land, by far more than the income that can be obtained from any other field crop.

The prevalence of various livestock diseases and parasites was reported to be among the major limiting factors to livestock production. However, the quality and efficacy of vaccines and veterinary drugs were recognized to be questionable. Moreover, distant location of veterinary clinics—more than 5 km radius— and irregular vaccination programs are issues that demand due consideration and immediate solution.

Even though more than 40 types of forage varieties have been released by research systems, the proportion of farmers who have adopted some of these is reported to be less than 10%. The major reason was recognized to be inadequate awareness and promotion of forage varieties coupled with limited access to seeds or seedlings of improved forage varieties.

Amid all the challenges, farmers still supply considerable quantity of milk to the market. For instance, it has been estimated that farmers of Grar Jarso district supplied about 113,000 liters of milk per day, out of which about 75% (more than 80,000 liters) is sold and channeled to the city of Addis Ababa, located at about 120 km radius from milk production zone. Sale of milk, however, is not a common practice in Ambo and Woliso, though they are located at nearly the same distance as Grar Jarso, because of

meager quantity of milk supply. More than 80% of milk supply to Addis Ababa is channeled from Selale route.

The major problems in the livestock sector include feed shortage, shortage of improved livestock breeds (mainly improved dairy heifers), prevalence of various livestock diseases and poor efficacy of veterinary drugs and vaccines, inefficient milk marketing system, shortage of pure water supply, and low awareness of farmers on available livestock technologies. Poor milk handling and hygiene is also the common problem of farmers in Selale milk supply route.

Practices and Challenges in Natural Resources Management (NRM)

In response to human population increase over time, fragmentation of farmlands has become acute leading to deterioration of soil fertility and decline in the productivity of crops and livestock. Consequent to this, farmers have started to cultivate steep slopes and communal grazing lands, cleared forests and threatened biodiversity. For instance, deforestation and degradation of land has caused extinction of indigenous tree species, such as *Hagenia absyssnica, Cordia africana, Prunus africana, Erica arbora, Coroton macckostachys, Acacia spp, Albizia spp, and Olea africana*. On the other hand, ecologically less friendly *Eucalyptus spp.* has been replacing indigenous trees and expanding at alarming rates for its use as construction material and fuel energy. Even though there are community-initiated by-laws that are run by committees to manage forest resources, they are not as such effective because of limited legal supports.

Even though there is a potential of water resources to develop irrigated agriculture, it has not been adequately utilized—except some of the farmers who practice traditional irrigation agriculture at small-scales. The major problem that contributed for underutilized irrigation potential is limited capital to build irrigation structures. Besides, inadequate use of irrigation technologies and limited linkage of farmers with markets have been contributing factors to less utilization of irrigation agriculture. The farmers are also constrained with packages of improved irrigation technologies, such as seeds and improved crop varieties, recommended fertilizer types and rates for each crop types, water requirement of crops, method of irrigation and others. Consequent to these factors, the available water resources have not yet been harnessed to strengthen resilience of farmers from climate change effects.

Use of agricultural implements and machineries was also found to be very limited in the study areas. For instance, AYBAR, a modified version of broad bed maker (BBM) for draining excess water has not yet been well disseminated. The use of AYBAR is

also believed to allow farmers to practice double cropping in a year, such as wheat, which can be grown in the main rainy season using drainage technology and chickpea in the later season. Row planter, especially for tef, is also the most demanded implement, which relieves farmers from arduous task of manual row planting and motivates more others to adopt row planting technology. Limited supply, however, is one of the reasons behind inadequate dissemination and use of AYBAR, row planters and other farm implements. Sustainable linkage has not been established between manufacturers of farm implements and the users.

The major problems related to NRM were identified to be increased acidity of soils and consequent decline in soil fertility over time; limited capital; knowledge and skills to harness irrigation potentials; inadequate use of irrigation technologies; and limited supply and use of farm implements.

Conclusion and Ways Forward

Diverse social, biological, environmental and policy factors affecting agricultural productivity, environmental sustainability, and overall farmers 'livelihoods have been identified and documented in this study. Even though in-depth case analysis has been conducted in selected districts, the recommendations can be applied not only to other districts, but also in other parts of the country with similar socio-economic, agro-ecological, and farming systems contexts. Future research and development planning by AGP-II and other programs should consider the identified problems as frontlines to design projects and further research initiatives. Despite details have been provided in the text, the following major recommendations have been proposed for interventions:

Proposed interventions in socio-economic studies

- Demonstration, scaling-up, promotion and dissemination of the already existing packages of improved agricultural technologies to women and men farmers;
- Adoption and impact study of agricultural production technologies;
- Assessment of the extent of access and utilization of rural finance and credit services to small-holder farmers and its influence in improving farmers' productivity, livelihoods and commercialization;
- Investigation of the impacts of agricultural extension approaches, tools and techniques on farmers' productivity and livelihood improvements;
- The study of development needs, challenges and employment opportunities of rural youth and their technology use status; and
- Establishment and strengthening of special purpose cooperatives for women depending on their interests.

Proposed interventions in crops research

- Strengthening formal and informal seed multiplication schemes of improved crop varieties;
- Demonstration and popularization of improved storage structures, such as PICS Bags and Metal Silo to minimize post-harvest losses due to storage pests (especially bruchids);
- Demonstration of chemical use and safe handling mechanisms;
- Developing high yielding crop varieties that are resistant to the already existing and emerging pests and diseases;
- Development and generation of climate-smart agricultural technologies in crops; and
- Strengthening research to generate resistant varieties and prevention mechanisms to emerging pests and diseases

Proposed interventions in livestock research

- Study on opportunity cost of using land for growing forages against food crops in order to generate evidence which helps farmers to make informed decisions on proper enterprise choice;
- On-station multiplication of seeds and/or seedlings of released forage varieties, and on-farm demonstration and promotion of available feed and forage technologies;
- Establishment and strengthening of informal forage seed production and supply scheme using cooperatives and model farmers;
- On-station multiplication (rearing) of crossbred dairy heifers, and improved chicken breeds; and
- Assessment of farmers' milk handling, hygiene and marketing practices.

Proposed interventions in NRM research

- Validation and transfer of technologies to ameliorate soil acidity;
- Characterization of agricultural soils for their biophysical and chemical properties at district levels;
- Testing and validation of the new fertilizer products containing both macro- and micro nutrients as per ETHIOSIS map;
- Determination of fertilizer recommendations and water requirements of irrigated crops along with other agronomic practices for efficient use of nutrients and water;
- Research on crop intensification, such as multiple cropping systems (double cropping in areas where the practice can be applicable), and cropping sequence (crop rotation with inclusion of legumes); and
- Establishing a data-base for soil fertility and nutrient management.

I. Background and Rationale

1.1 Agricultural Growth Program (AGP)

Agriculture sector of Ethiopia has been striving to enhance economic growth especially in the GTP-I period. In the same period, overall economy has been growing at the rate of 11% per annum for which AGP has also been one of the development initiatives that made substantial contributions. AGP is a multifaceted investment program supporting agricultural productivity and commercialization focusing on high agricultural potential areas to address some of the key constraints to agricultural growth and thereby contribute to overall economic growth and transformation. It is a program approach, which is being viewed as one of the key investment mechanisms for development partners and government to collaborate on.

Following completion of AGP-I, the Second Agricultural Growth Program (AGP-II) was made to be aligned with GTP II, thereby contributing to the achievement of targets set for the growth of agriculture sector. AGP-II was designed based on the lessons and best practices of AGP-I to improve implementation and maximize the overall impact of the program. The overall objective of AGP-II is to increase agricultural productivity and commercialization of smallholder farmers targeted by the Program and also contributes to dietary diversity and consumption at HH level.

AGP-II operates in 165 districts selected from seven national regional states and one city administration of the country which have the highest growth potential, primarily based on agro-ecological conditions and access to markets. The 96 districts that benefited from AGP-I interventions are also beneficiaries of AGP-II to consolidate past achievements and strengthen capacities built. In the second phase of the program, additional 61 districts drawn from the following regional states were included: Amhara, Oromiya, SNNPR, Tigray, Benishangul-Gumuz, Gambella, Harari and Dire Dawa City Administration. To address the objectives, AGP-II adopts the following approaches:

- Comprehensive schemes responding to national strategic goals;
- Demand driven and decentralized (participatory) approach;
- Focus on selected areas and value chains;
- Considers cross cutting issues particularly, gender, nutrition and climate smart agriculture (CSA);
- Sustainable approaches through enhancing capacity of actors in development; and
- Mechanisms that enhance complementarities and linkages within and between the different components of the Program, and other Programs and projects within Ministry of

Agriculture and Natural Resources (MoANR) and Ministry of Livestock and Fisheries (MoLF).

AGP-II also builds on experiences and lessons learnt from implementation of AGP I and is composed of the following five components:

1. Agricultural Public Support Services;
2. Agricultural Research ;
3. Small Scale Irrigation;
4. Agricultural Marketing and Value Chain; and
5. Program Management, Capacity building, and Monitoring and Evaluation. In addition, the program would support the mainstreaming of cross-cutting issues (gender, nutrition and CSA) across the above components.

1.2 Rationale for the study

Component 2 (Agricultural Research) of AGP-II embraces four sub-components including:

- Technology adaptation and generation;-
- Pre-extension Demonstration and Participatory Research Schemes
- Source Technology Production
- Capacity development to enhance technology adaptation, generation, maintenance and promotion

Out of these sub-components, the first one "Technology adaptation and generation" is devoted to support the adaptation and generation of improved and innovative technologies to enhance agricultural productivity and commercialization of small scale farmers. In order to generate appropriate technologies that are easily adoptable, environmentally friendly, technically viable, economically feasible and gender responsive, a study was conducted and information was generated on the prevailing status of agricultural production, constraints and available opportunities. This report, therefore, presents the findings of the study and also provides recommendations proposed to address the constraints. The information generated will fundamentally serve as the basis for making informed decisions on subsequent steps, such as planning research activities for technology generation, adaptation, demonstration, promotion and dissemination, and capacity building. The information will also be used as a baseline with which end-line findings will be compared after termination of second phase of AGP.

1.3 Objectives of the Study

General Objective

Characterize the farming systems of AGP-II districts and identify production constraints.

Specific objectives

- Characterize the interrelationships of integrated farming systems components, such as crop and livestock production, and natural resources management;
- Assess accessibility, affordability and utilization of improved agricultural technologies by the farming community;
- Explore gender perspectives in extension services, technology use, resource availability, economic capacities, food availability and other livelihood dimensions;
- Investigate adaptation and coping mechanisms, mitigation and extent of resilience of the farming households to climate change and/or variability;
- Identify and prioritize major bottlenecks limiting agricultural production and productivity; and
- Suggest feasible and applicable development, research, extension and policy intervention options that are believed to ensure lasting and sustainable improvements in the livelihoods of farming households

2. Methodologies and Approaches

The study adopted participatory approaches actively involving the farming community and other development partners. These approaches are described as follows.

2.1 The Study Locations

The study focused on the central highlands of Ethiopia with particular emphasis on North Shewa, West Shewa, and South West Shewa Zones of Oromiya Region. Even though sample districts were selected for in-depth farm level case analysis, the findings and suggested interventions could be applied in other districts as well in these zones.

AGP-II Zones embrace 14 districts supported by AGP-II. These included Ambo, Dendi, Bako Tibe, Ejere and Toke Kutaye in west Shew zone; Dera, Grar Jarso, Hidhabu Abote, Wara Jarso and Yaya Gulele in North Shewa Zone; and Becho, Kersa Malima, Wenchi and Woliso in Southwest Shewa Zone. These woredas have different agro-ecologies ranging from typical highlands with annual rainfall of up to 1000 mm characterized as *Dega* to moisture stress low land areas characterized as *Kolla,* which provides ample opportunities to grow different types of crops and at the same time have different production constraints to boost associated production.

West Shewa Zone: This Zone is characterized by mixed crop-livestock farming systems. in this zone include Ambo, Dendi, Toke Kutaye and Ejere.

Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), this Zone has a population of 2 million, of which 50% each were male and female. While 94% of the population are rural inhabitants the rest are urban dwellers. With an area of 14,789 square kilometers, West Shewa has a population density of 139.2 persons per square kilometer. The average rural household has 1.4 hectare of land, a little higher than the national average of 1.01 hectare and an average of 1.14 hectare for the Oromia Region. Apart from agriculture, 32% of the population in the zone is engaged in non-farm related jobs, compared to the national average of 25% and a regional average of 24%.

West Shewa Zone is also reported to have ago-ecological suitability for the production of different crops including tef, wheat, maize, barley, faba bean, and chickpea. The agro-ecology of the zone is characterized by 40% mid altitude, 27% highland, and 33% lowland. Among the improved crop technologies being introduced and disseminated in the zone, maize accounts for the largest share—more than 55%— of

the area coverage followed by barley and faba bean each accounting for 10% of coverage. However, an increasing trend has been perceived for tef and wheat production, wheat is reported to be highly susceptible to different diseases, such as yellow rust and others.

Apart from its essential contribution as source of draft power and food and nutrition, livestock sector is one of the key sources of income for the households in West Shewa Zone. However, climate change/variability and human population pressure are becoming detrimental to the growth of the sector not only in the zone, but also in the country, in general. Frequently occurring drought and rainfall variability are reported to have caused feed shortages while per capita availability of grazing and pastureland is diminishing over time due to human population pressure. The consequent effect of all these factors has resulted in low productivity of the livestock sector.

North Shewa Zone: This Zone features crop-livestock farming systems. The Zone has highlands accounting for 42%, mid-altitudes 35%, and lowlands 23% The five districts include Girar Jarso, Yaya Gulele, Hidhabu Abote, Dera and Wara Jarso.

Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), this Zone has a total population of 1.4 million of which 50% each were male and female. With an area of 10,322.48 square kilometers, the zone has a population density of 138.66 persons per square kilometer. While 90% of the population lives in rural areas, the rest were urban dwellers. The average family size of the zone was 4.6 persons per household. The average rural household had 1.1 hectare of land which is almost equivalent to the national average of 1.01 hectare and an average of 1.14 for the Oromia Region. About 15% of the population in the zone is engaged in non-farm related jobs, which is considerably lower than the national average of 25% and a regional average of 24%.

Southwest Shewa Zone: The Zone is known for its mixed crop-livestock farming systems. Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), this Zone had a total population of 1.1 million of which 50.5% are male. About 86% of the population lives in rural areas. The average household size of the zone was 4.7 persons. The Zone includes Becho, Woliso, Wenchi, and Kersa Malima districts.

2.2 Data collection

Blends of tools and techniques were adopted to collect the required information and dataset that address the objectives of the study. The two standard data collection techniques and approaches employed in this study included desk reviews and

qualitative survey techniques. The first stage focused on generating secondary information while the second stage targeted in collecting primary information from target respondents using a checklist. Each of the study methodologies as follows:

2.2.1 Desk review

In the first stage of data collection, secondary information was exhausted from published and unpublished documents of EIAR, CSA, AGP, and other governmental, non-governmental, and international partners. Some of the major sources of published secondary information included journals, books, proceedings, manuals, CSA publications, unpublished reports, and others. These sources were accessed in both electronic and print media.

2.2.2 Qualitative survey techniques

In the second stage, blends of qualitative survey methods including PRA tools and other participatory approaches were adopted to collect primary information from the farming community and staffs of zone and district level Agriculture Offices. A team of professionals drawn from different fields of specializations conducted the whole study including data collection.

Using blends of participatory tools and techniques has helped to triangulate the information obtained from different sources. The most important participatory tools and techniques employed included focus group discussions, key-informant interviews, individual interviews, matrix rankings—direct and pair-wise matrix—proportional pilling techniques, diagramming, historical profiles, and photographs.

In-depth farm level analysis was carried out in two Districts, Ambo, and Girar Jarso, selected from West and North Shewa Zones, respectively. In addition, the study has intensively exhausted secondary sources from three of the AGP-II zones with a focus on farming systems constraints and opportunities available. The study team was drawn from four research directorates of Ethiopian Institute of Agricultural Research (EIAR) including agricultural economics, crops, livestock, and natural resources management. In each of the zones, the team members made in-depth focus group discussions and key informant interviews with respective directorate staffs of offices of agriculture. This approach has helped to capture extensive information not only about the zones but also about agriculture potentials and constraints. The information obtained from zonal and district levels was triangulated and substantiated with in depth focus group discussions with sample farmers.

The study team made an in depth farm level analysis in Ambo and Grar Jarso districts. In addition to this, the team has made discussions with Agricultural Extension, Crops, Livestock, and Natural Resources Department staffs of West, North, and Southwest Shewa Zones.

Farmers who participated in the discussion were selected based on prominent indicators, such as wealth status, age, sex, technology use practices, literacy status, specific type of farming practices and others. Farmer selection was made in consultation with and inputs from office of agriculture staff.

In each of the target sites, the sample farmers were grouped into four categories to undertake discussions with each of the social, crops, livestock and NRM team members. Each group comprised more than 10 farmers, out of which about 30% were women.

2.3 Information synthesis and report writing

The information collected was synthesized and organized according to a pre-determined outline of the report. Draft report writing started during fieldwork especially for the information collected from zonal and district offices of agriculture. The study team was making scores of meetings to brainstorm essential issues and craft contents of the draft report. A write shop was also organized for the team to analyze the data, synthesize information, and generate a draft report.

3. Findings

3.1 Socio-economic characteristics

During discussions with zone and district offices of agriculture staff and the community, ranges of socio-economic issues were assessed, the findings of which have been presented in subsequent sections. Focus was made for such factors as wealth ranking; public services, such as extension, communication and transportation services, income source and saving practices, climate change/variability, household food security, and farming dynamics.

3.1.1 Wealth status

As per the perception of the community, households are categorized into different wealth categories depending on agro-ecological features. In the highlands, the most important wealth indicator to rural households is often ownership of livestock, especially oxen and cows. In the lowlands, food availability was identified to be the key indicator to categorize farmers in different wealth strata. This is attributed to climate change, which was brought about by drought and unreliability of rainfall.

In the context of highland agro-ecologies, relatively well-to-do (wealthy) households are those who own more than 10 cattle with a pair or more of oxen for farm operations (Table 1).The farmers perceive that large livestock ownership ensures high production of grain and livestock products such as milk and butter. The implication is that such households can also afford to purchase inputs including new agricultural technologies and they are often risk takers in trying new technologies. They are food secured and their income sources are often diversified including bee keeping, poultry, and others.

During demonstration of new agricultural technologies, they dare to take risks and host the experiment. Extension agents usually target these households to demonstrate new agricultural practices since they can afford to apply full packages of technologies. Even though there could be variability from location to location, such households, however, account for a very small proportion in the community, often 10% or less.

In the context of lowland agro-ecologies, wealthy farmers are those who can produce and cover food demands of their households for nine months in a year. They adopt various practices to achieve this level of food security, such as the use of small-scale irrigation, short maturing varieties, soil and water conservation practices, and others. When, this category of households runs out of own food for three months in a year, they take various options to purchase grain, such as sale of assets and engagements in off-farm businesses.

Medium wealth categories in the context of highland agro-ecologies often own a pair of oxen. Apart from agricultural produce, they also strive to generate supplementary incomes through off-farm activities (IGAs), such as petty trading. Despite not as much as well-to-do households, they make all the efforts to afford purchases of inputs, send their children to school, and produce food for their family. They are not, however, food secured and economically strong as the rich wealth category. They have to strive further and enhance their economic capacity through technology use and other options of income sources. According to farmers' estimates, this wealth category accounts for about 40% of the population in spite of variability from one location to another.

In the context of lowland agro-ecologies of the study areas, medium wealth category households are defined to be those who can produce and cover food demands of their households for seven months. That means they have to run food insecure and look for other options to sustain a living for five months in a year, such as engagements in IGAs, and sale of meager assets. On the other hand, the resource poor households account for about half of the population. Most of them do not own an ox, the key farm resource. In most cases, they share or lease-out their farmlands to rich or medium wealth households. Because of this, they are food insecure and often depend on daily labor as source of their major income. The community perceives that these categories of households are not expected to adopt new technologies, as they cannot afford the inputs. They are instead risk averse and hesitate from adopting new technologies and practices. Illiteracy is also perpetual in such households, as they cannot afford to send their children to school. They are also vulnerable to diseases due to poor and inadequate nutrition. Given the high proportion they account in the population, focus should be given for such categories of farming households to improve their livelihoods.

Households categorized as poor farmers in the context of lowland agro-ecology can produce and cover food demands only for five months. This means, they have to run food insecure for seven months in a year and find a living through various options, such as looking for government supported productive safety net program (PSNP), engagement in daily labor, migration to towns, and others.

Table 1. Characterization of wealth status of the highland agro-ecology

Wealth category	Livestock ownership	House type	Land ownership status	Other livelihood factors	Estimates through proportional pilling tool (%)
Rich	▪ 10 or more cattle out of which 6-8 are cows. Produce milk throughout the year ▪ Own > 70 shoats (sheep and goats) ▪ Own mule and horse	Corrugated roofed with painted walls	Large size of land than other categories out of which 0.25 ha is allocated to eucalyptus plantation	▪ Can afford to send children to school ▪ Food secured with production adequate for more than 12 months and excess for market ▪ Own house in urban centers with TV and radio access ▪ Access to solar energy source ▪ Diversified income sources, such as bee-keeping ▪ Bank savings	10
Medium	About 6 cattle out of which about 2 are cows and a pair of oxen	Corrugated roofed, but not wall painted	Own about 2 ha of land out of which 0.125 ha is allocated to eucalyptus production	▪ Engaged in off-farm IGAs, such as petty trading ▪ Food secured for 12 months, but no adequate supply for market ▪ Can afford to send children to school ▪ Bank savings	40
Poor	Mostly no ox, but some of them can own only one.	Grass-roofed	Own 0.5 – 1 ha of land which is often leased out	▪ Mainly engage in daily labor ▪ Often affected with poor nutrition ▪ Very low economic status ▪ Food insecure for 3 – 6 months	50

Dynamics of credit services

Even though there are ranges of services being accessed for public, this study focused on assessment of the status of credit, extension, communication, and transport services. Even though sources of agricultural credit can be broadly classified into institutional and non-institutional, the focus of the discussion in this report was on institutional source of credit, mainly Micro Finance Institution, which is relatively accessible to the farmers.

Micro finance institutions

At the time of discussion with experts, the major sources of rural credit at the farmers' proximity are micro finance institutions, including *WALQO, WASSASA, ESHET, WISDOM, VISION FUND, and BUSA-GU NOFA*. In spite of availability of options of credit sources, it was estimated that agricultural credit institutions account for approximately 3% of the total rural population. However, a slightly increasing trend is being observed in recent years. For instance, the share of these financial credit institutions out of the total agricultural credit was estimated to have increased to nearly 8% in 2017 as compared with only 5% in 2012. The implication, however, is that these institutions still have a long way to go and access large proportion of rural households.

Given the fact that 90% of the rural population falls in the range of poor and medium wealth category, creating access to favorable credit services for these households becomes a fundamental issue that needs to be set as one of the priority agenda. This is because it has an implication on utilization of agricultural technologies without which the growth of agriculture sector cannot be ensured on sustainable basis. While the finding of this study disclose the large proportion of resource poor and medium wealth households on the one hand, the other hand tells us that credit institutions have not yet accessed more than 90% of the farming population.

Challenges of agricultural credit institutions

The credit sector is trying simultaneously for meeting financial requirements of the farmers. However, the following challenges were identified requiring due attention to improve efficiency and effectiveness of credit services for smallholder farmers

- **Insufficiency:** In spite of expansion of rural credit structure, the volume of finance available for rural credit in the country is still insufficient as compared to its growing requirement arising out of increases in prices of agricultural inputs.
- **Inadequate amount of sanction:** the amount of loan sanctioned to the farmers by the institutions is also highly inadequate for meeting their demands. Consequently, the farmers were not able to purchase packages of inputs and new technologies that help boost

production and productivity. When the amount of loan sanctioned gets small in amount, the farmers get desperate and opt to spend in unproductive duties which are against the very purpose of such loan.

- **Censored attention for poor households:** rural credit institutions and their schemes have failed to meet the needs of the small and marginal farmers. Thus, lesser attention has been given on the credit needs of the needy farmers while comparatively well-to-do farmers are getting more attention from the credit agencies for their better credit worthiness.
- **Growing over dues:** the problem of over-dues in agricultural credit continues to be an area of concern. The recovery of agricultural advances to various institutions is also not at all satisfactory. Such growing over-dues have also resulted from poor repaying capacity of farmers. As a result, they are becoming wary of granting loan to farmers especially requesting them to form groups and make initial deposits with high interest rate and even the service charge.
- **Less favorable conditions for smallholder farmers to access credit services:** It has also been reported that the pre-conditions to get credit service is quire less favorable for small holder farmers. For instance, the mandatory rules to access credit from the institutions include:

    - Group formation;
    - There should be a group saving account and an individual too; a household should save about 10% of the loan for 3-6 months;
    - Obliged to pay insurance-which is non-refundable; and
    - At the initial period, they should pay the first year interest rate, which is estimated to be 18% of the gross loan.

- **Inadequate institutional coverage:** Institutional credit arrangement continues to be inadequate as compared to its growing needs. The development of credit institutions indicated in the preceding sections has failed to cover the entire rural farmers who are demanding credit for agricultural input.
- **Red Tapism:** Institutional farm credit is subjected to red-tapism. Credit institutions are still adopting cumbersome rules and formalities for advancing loan to farmers which ultimately forces them to depend more on costly non-institutional sources of credit.

Thus, to remove limitations and problems of agricultural input credit in the district, the following suggestions were figured out after having discussions with zonal and district office of agriculture experts:

- Close monitoring of the input credit institutions;
- Credit institutions should be organized in such a way to ensure efficiency and be purposeful in delivering best services in terms of rural farm input credit. Moreover, they may be transformed into multi-purpose institutions with sufficient funding capacity;
- Facilitators (intermediaries) existing between credit agencies and farmers should be excluded;

- The federal Government, regional, zonal and district administrators should introduce the credit guarantee scheme to provide guarantee on behalf of the farmers for getting loans;
- The credit institutions should adopt procedural simplification for credit delivery through rationalization of their working pattern; and
- Credit institutions should also monitor over the actual utilization of loans by developing an effective supervisory mechanism to increase productivity through adoption of technologies.

Agricultural extension services

A core focus of the government's investment in agriculture is the public agricultural extension system. Farmers' training centers (FTCs) were established to facilitate extension service provision and enhance farmer-to-farmer learning. The problem, however, was that 50% of the FTCs were not functional for the purpose they are established. Even those reported to be functional were not operating to their full capacities for such reasons as limited operational budget and shortage of their own plot of land for experimentation.

Farmer to DA ratio is getting better now a days. Before two decades, DA to farmer used to be more than 1:10,000—one DA serving more than 10,000 farmers. However, this ratio has improved significantly to such estimates as 1:1200 even though the quality of extension might still need to be improved further.

Access of smallholder farmers to agricultural technologies was observed to experience gender disparity with men still having better access compared to women and youth. For instance, men participation is higher in access to trainings, field days and experience sharing visits compared to women and youth. As a sample, case analysis has been made in Ambo district to illustrate extent of participation of men, women and youth in extension service. Table 2 provides that 67% of men have participated in scaling-out program of crop production technologies while it is 20% and 13% for women and youth, respectively. In scaling-out program of livestock production technologies, the levels of participation were reported to be 60%, 21% and 19% for men, women and youth, respectively. Given gender blind approach of extension service provision that has been prevalent in the past decades, involvement of women and youth in the recent extension systems could be considered as encouraging progress. In recognition of their participation in agricultural activities, participation of youth, especially, in the extension service program is highly appreciated.

Table 2. Proportion of extension participants in agricultural technologies scale out programs in Ambo district

Technology	No. extension participants	% of participants		
		Women	Men	Youth
Crop related	13,919	20	67	13
Tef technologies	3504	14	68	18
Wheat row planting	7957	24	64	12
BBM technology	2458	17	73	10
Livestock	4354	21	60	19
Synchronization	1632	22	59	19
Artificial insemination	1487	21	60	19
Bee keeping	1235	21	60	19
Gully rehabilitation	3344	15	65	20
Total	**39,890**	**20**	**65**	**15**

Source: Ambo district agricultural development office (2017)

In spite of participation, it was noticed that not all of the men, women and youth were effectively utilizing the technologies that have been promoted to them during scaling-out programs. For instance, out of 9300 men who have been participating in crops related scale-out programs, only 54 of them were reported to have utilized effectively (Table 3). In the same way, 60% of women and 83% of youth have utilized the technologies effectively. Overall, 56% of scaling-out program beneficiaries on average utilized various technologies effectively (61% women, 50% men and 70% youth). The factors that attribute to effectiveness of technology utilization were identified to be wealth status, training advancement, capacity of implementation, land size, educational level and land fertility, and agro-ecological setting of the intervention area. It is inspiring to notice here that youth are observed to have utilized the technologies more effectively than men and women farmers. This might be because of their better access to education and positive attitudes towards new technologies.

Table 3. Proportion of participants who have utilized agricultural

Technology	Technology users (%)			
	Overall average of technology users	Women	Men	Youth
Crop related	59	60	54	83
Tef technologies	42	63	38	44
Wheat row planting	63	55	60	95
BBM technology	69	82	58	133
Livestock	55	100	39	55
Synchronization	22	13	22	33
Artificial insemination	18	19	14	32
Bee keeping	79	100	71	79
Gully rehabilitation	52	42	56	50
Total	**56**	**61**	**50**	**70**

Source: Ambo District Agricultural Development Office (2017)

The livestock based extension focused on provision of vaccination and AI services. Farmers have been pleased with likely genetic improvement of local cows via AI services even though its effectiveness was reported to be below expectation. As illustrated in Figure 1, the vaccination service revealed a fluctuating trend over years mainly in response to the status of disease occurrence. For instance, vaccination service for cattle reveals a rising trend over years while others illustrate almost a stable trend on the average. In 2015, the vaccination service was high for poultry because of such diseases as Newcastle Disease (NCD), Infectious Bursal Disease (IBD) and Salmonellosis. In spite of the vaccination, however, farmers' per capita holding of chicken has decreased afterwards. Timely and effective vaccination is, therefore, a mandatory extension service to enhance farmers' economic status, ensure food security and nutrition, and overall livelihoods.

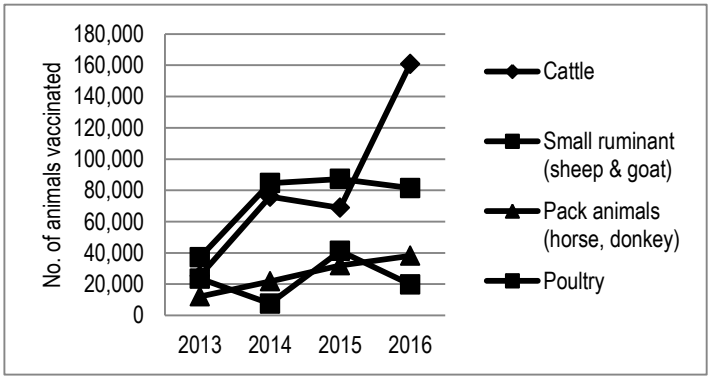

Figure 1. Trends of extension in vaccination service delivery by livestock type

Basic infrastructure and resources at the FTCs remain a major constraint, particularly in relation to operating funds and access to demonstration field. It was also observed that the vast majority of FTCs do not have operating equipment or inputs to pursue typical extension activities on demonstration farms. There are major "soft" skill gaps for DAs and subject matter specialists (SMSs) in the FTCs, and their ability to serve farmers is limited given a lack of practical skills for the existing and new agricultural technologies. Finally, the overall field-level system is often limited and constrained in its ability to meet farmer needs and demands. Therefore, mechanisms to make it more farmer-driven and market-oriented would yield greater results. Various aspects of enabling environments were considered, including seed and other inputs, water management, and credit systems, as well as producer groups. Constraints were also assessed, leading to the conclusion that the enabling environment requires strengthening, particularly in the areas of seed type with different potential verities, different agronomical and protection innovations in entomological, weed, and

pathological problems, and credit, if extension system is to achieve its full potential impact. It was also perceived that the extension service was mostly skewed to crops with very limited concern to livestock.

Taken as a whole, the following cohesive sets of actions have been suggested to strengthen the extension system

- **Farming system-driven orientation**: across all levels of extension, focusing on farmers' demands with need assessment at the district levels is essential. The overall supervision and orientation of the extension system must be driven by farmer needs, from the types of services offered at each FTC to the overall strategic direction. A farming system-driven orientation ensures that the extension intervention is serving farmers in their areas of highest need and allows for the regional and district level intervention required in an agricultural system. This orientation must be balanced from bottom-up, horizontal and top-down planning to ensure food security with the required nutrition and environmental conservation;
- **Expansion of extension services offered**: Extension services need to be accessible to more and more men, women, and youth farmers in the community. Packages of technologies need to be promoted to ensure maximum benefits and sustainable impact as per the needs of beneficiaries. Knowledge and skills of all the beneficiary farmers including women and youths need to be enhanced through various on-the-job, FTC based, experience sharing and other mechanisms. This helps to increase the number of technology beneficiary farmers and enhance productivity;
- **Strengthening FTCs for impact and sustainability of agricultural technologies**: The findings indicate that many of the FTCs are not fully functional mainly due to lack of adequate resources, such as extension facilities. The budget allocated to FTCs is also meager, if there is one, to meet the demands. It has been suggested that beneficiary community need to contribute a certain amount on voluntary basis to strengthen FTCs and capacitate them to generate their own incomes from demonstration and other activities;
- **Build and strengthen the capacities of DAs**: Even though DAs are a minimum of diploma level graduates, there is a need to strengthen their knowledge and skills with practical oriented short-term trainings and exposure visits. Ranges of short-term trainings on various themes are fundamental in addition to on-the-job practical demonstrations and learning. Experience sharing to model sites could also enhance their exposure to application-based interventions. It is also essential to strengthen incentive mechanisms for DAs through reward, promotions, providing opportunities for higher studies and others. There is also a need to strengthen a clear DA career path with a focus only to technical deliberations and professional ethics. It has been repeatedly emphasized that DAs should focus on technical matters without involvement in other non-technical issues to discharge their professional services to the maximum of their knowledge and skills; and

- **Strengthening stakeholder linkages throughout the system**: In recognition of the importance of a system wide approach to extension, the need has become evident that collaboration and linkages need to be strengthened among the key stakeholders that have a stake in the agricultural extension systems. Along with Office of Agriculture, other actors such as research institutions, input suppliers, traders and processors, farmers, seed multiplication agencies, private crossbred heifer rearing companies and animal health providers, NGOs, higher learning institutions and others need to strengthen and maintain strong linkages through various platforms. There shall be responsibility and resource sharing mechanisms, experience sharing and information exchange systems among these stakeholders. ADPLAC could also be taken as one of the opportunities to strengthen stakeholder linkages.

Access to communication services

Information and communication technology (ICT) can play a critical role in facilitating rapid, efficient, and cost effective knowledge management in scaling out of agricultural technologies. However, ICT application remains low even though mobile phone use practice is tremendously increasing from time to time. It has been estimated that more than 50% of the farmers communicate about prices, technologies and other agriculture related information through their mobile phones. Except the complaint on poor network services in some of the locations, the practice of listening to radio through mobile phone has also been inspiring among the farming communities. Focus on expansion of strong network coverage by the government could significantly transform the farmers' practice of ICT use and exposure to agricultural information.

The FTCs are established to facilitate agricultural knowledge and information exchange among researchers, extension workers, and farmers. District agricultural offices are responsible for managing the operation of FTCs with the support of zonal and regional agriculture bureaus and are the frontline administrative structures for implementing agricultural extension services in the country. Following apparent network coverage in rural areas, communication through mobile phones is also getting a popular approach facilitating extension services. ICT can play a crucial role in benefiting the resource-strapped farming communities with up to date knowledge and information on agricultural technologies, best practices, and market price trends.

The experiences of most districts closer to the zonal towns or urban centers indicate that rapid development of ICT, which facilitates the flow of data and information, has tremendously enhanced the knowledge management practice in agriculture technologies as stated by the district agricultural office experts. However, currently, among the various ICT related initiatives, radio is widely used to share and inform users on agricultural issues, including new and upgraded farming techniques and production management, market information, and other issues. Due to its strategic

importance in reaching the majority of the smallholders, only few attempts have been made to strengthen the delivery of knowledge and information through this media.

The way forward for ICT to contribute for agricultural development in the districts include the following:-

Knowledge and information management in the agricultural sector will be achieved when the right knowledge and information is delivered to the household and other stakeholders at the right time in a user-friendly and accessible manner. To realize this, households in the farming community should be involved in the knowledge management process as knowledge generated in a participatory manner has a greater likelihood of being accepted and acted upon by the households. This participatory approach will also enable the integration of traditional or tacit knowledge of farmers with modern forms of knowledge in the research community, and further improve utilization of knowledge disseminated to smallholders.

Instigating modern approaches to knowledge management: In the districts crops, livestock, and NRM are operated under different challenges. While recognizing that the districts have a few institutions and organizations engaged in the creation and dissemination of agricultural knowledge and information, effectiveness is inhibited by the limited network coverage and inadequate usage of ICT. Men headed households have more access to the ICT platforms compared to women-headed households as stated by agricultural experts. The reason behind this was attributed to economic factors where male-headed households have better access and control over resources than female-headed households. So strengthening women's economic capacity as well is advisable.

Access to road facilities and transport services

Like many other economic and social activities that are intensive in infrastructure, the transport sector is an important component of the economy affecting development and the welfare of the people (Rodrigue *et al.,* 2011). When transport infrastructure is efficient, it provides various economic and social opportunities and benefits that result in positive multiplier effects such as better accessibility to markets, employment, education, health, and additional investments (Oosterhaven and Knaap, 2000). Farmers have access to transportation services though the extent varies from one district to another and even from one peasant association (PA) to another within a district. For instance, in Ambo District PAs have 90% access to seasonal road and transport services. Most of the PAs have access to seasonal road while a few of them still did not have access to road and transportation services. In Ambo District, for instance, 84% of the PAs have access to seasonal road while others have no access to

seasonal road and transportation services. Establishment of transport services within PAs, and PA to district towns directly or indirectly facilitates output-marketing system for households, and access to inputs and technologies.

Food security status

Despite at slower pace in the face of climate change challenges, cereals production showed an increasing trend over years. For instance, in the last five years in Ambo district, cereal production has increased with an average productivity of 2.9 tons per hectare, which is better than below 2.0 tons per hectare in the last decades.

The livestock resource is making a substantial contribution to household economy and food security. However, the milk production per local cow/per day was not more than 2.5 liters over lactation period of 180 days. Upgrading genetic potential of dairy cows is, therefore, essential to enhance household food security and economic benefits.

The study has also revealed that compared to the past 20 years, food shortage is becoming a common phenomenon because of such factors as population pressure and climate change in which the production growth is not in par with food demand. This problem can, however, be solved with technological interventions that can cope-up challenges of population pressure, land infertility, climatic, and natural resource degradation. Women and children are especially more vulnerable to food insecurity than men as their access to and control over resources such as cash is limited.

Farmers can consider options of mechanisms to enhance their income and food security status. The study has demonstrated how this can be achieved by taking Ambo district as a case. According to the findings, tef accounts for the highest share in terms of area coverage (31%) followed by wheat (29.5%). Therefore, there is a need to promote improved technologies of these crops to ensure food security of a large proportion of the population. Among the cash crops, chickpea occupies 5.3% and lentil 3.8% of the total cultivated area indicating that increasing the productivity of these crops with improved technologies can also enhance the possibility of cash generation for the households.

An assessment of comparative advantages in production and market price indicates that high productive crops fetch relatively lower prices while less productive crops reward higher prices. For instance, the average yield per hectare was 3.7 tons for maize, 3.1 tons for sorghum, 2.8 tons for wheat, and 2.1 tons for barley. However, the average local market price for these crops varied from 6000 to 8000 Birr per ton. On the other hand, the yield of tef, chickpea, and lentil was 1.8, 2.3, and 1.8 tons, respectively, per hectare. The average local market price for three crops was ETB

20,000, 24,000, and 21,000 per ton, respectively. Therefore, interventions to increase yield of these less productive crops with agricultural technologies can have comparative advantage in enhancing farm incomes. Price advantage is one of the factors helpful for decision making in output marketing. Intervention of technologies with comparative advantage in price and yield can have a high degree of probability to gain sustainable income and to ensure food security, with the necessary nutritional requirements.

The search for long-term solutions in the fight against food shortage and malnutrition is at the very heart of technology generation, promotion, and scaling out. Both crop and livestock production makes 95% of the livelihood bases of districts such as Ambo, while the rest 5% is contributed by trade and off-farm activities. These calls for the need to further intensify scaling out, promotion and dissemination of available crops and livestock production technologies in order to enhance the livelihood bases and resilience of the farming communities on sustainable basis.

Gender analysis and estimation of workloads

Gender roles in farming

The role of female farmers in crop production and management is significant, with estimated extent of 55%. For example, it was estimated that women contribute labor required for weeding, transporting, storing, and managing the crop (Table 4). In women headed households, this figure definitely increases. This fact is in conformity with the study conducted in Ambo district (Ogato *et al*., 2009).

Table 4. Extent of participation of household members in crop production

Activity	Men	Women	Youth	
			Male	Female
Land plowing	85	0	15	0
Weeding	40	30	10	20
Harvesting	60	15	15	10
Threshing	90	5	5	0
Transporting the grain to storage	25	45	5	25

The study has also assessed extent of participation of women, men and youth in livestock production activities as illustrated in Table 5 for Ambo Woreda and Table 6 for Grar Jarso. The findings indicate that all family members are involved in livestock management related activities with varying levels of participation. For instance, during case analysis at Ambo district, estimations indicate that women alone shoulder the highest share of about 46% of the different livestock management operations while the rest 54% of the management activities are shared between men and youth (Table 5).

Livestock development experts have even estimated that women perform about 60% of the livestock management operations.

Similarly, the highest share (36.9%) of the different livestock management operations was accomplished by women followed by men (32.3%) and youth (30.8%) in the case analysis of Girar-Jarso (Table 6). The most laborious and routine activities such as feeding, cleaning barns and animals, milking and churning are mainly shouldered by women, which was also attested by the district livestock production experts. Men also have considerable involvement in different livestock management activities including milking, selling milk and to some extent churning as opposed to the case at Ambo. According to the respondents, operations related to management of milk/milk products and milking animals were traditionally the responsibility of women for local cows. The role of men in managing milking cows and milk/milk products becomes more apparent with the introduction of crossbred cows in response to an increase in milk output and development of milk market. This shows how technological interventions and the associated improvement in productivity can change gender roles in livestock/dairy production systems.

In spite of the figures, the participation of women in livestock management activities was considerable. Most laborious and routine operations such as feeding, cleaning, milking, milk processing, and fetching water over long distances for women accomplish livestock managed around homesteads. Moreover, they are required to shoulder other routine home keeping activities and various social responsibilities, which triple their workload. Studies by Agajie *et al.* (2016) showed that men are mostly given priority to participate in different awareness building programs such as trainings and experience sharing visits despite the fact that women are responsible to shoulder most of the livestock management operations. Such unbalanced targeting cannot lead to the anticipated improvement of the sector. Therefore, there should be fair consideration of the different family members in capacity building programs, technology demonstration, and promotion based on their level of involvement in the various livestock management activities.

The study has also figured out gender disparities in making household level decisions. In male-headed households, women have less power in making decisions on general farm operations and practices. For instance, if a woman wishes to plant some vegetable crops, it is hardly possible to implement her idea without the consent and decision of her spouse. On the other hand, women do have great job burdens whereby almost all the in house activities are the sole responsibilities of women in addition to their farm level contributions. In recent years, however, there are some indications that the greatest burden on women is tending to decrease because of men involvement in

activities customarily performed by women such as fetching water, firewood and others. Moreover, men are supportive in adopting family planning practices, which help reduce child bearing thereby easing women job burdens.

Table 5. Extent of participation of family members in livestock production related activities

Livestock management	Participation (%)		
	Men	Women	Youth
Housing (house preparation)	50.0	33.0	17.0
Feed collection and storage	43.0	29.0	28.0
Feeding	28.5	51.5	20.0
Watering	23.5	29.0	47.5
Health care	47.5	37.5	15.0
Cleaning	16.5	58.5	25.0
Milking	1.0	81.0	18.0
Churning	1.0	64.0	35.0
Herding	35.0	24.5	40.5
Selling milk products	0.0	71.5	28.5
Selling live animals	54.0	26.5	19.5
Mean	27.3	46.0	26.7

Table 6. Extent of participation of family members in livestock production related activities in Grar Jarso District

Livestock management	Participation (%)		
	Men	Women	Youth
Housing (house preparation)	45.5	30.5	24.0
Feed collection and storage	43.5	29.0	27.5
Feeding	35.5	36.5	28.0
Watering	24.5	35.5	40.0
Health care	51.0	29.0	20.0
Cleaning	23.5	42.5	34.0
Milking	29.0	48.5	22.5
Churning	8.5	55.0	38.5
Herding	22.5	27.0	50.5
Selling milk	26.0	19.0	55.0
Selling milk products	8.0	72.0	20.0
Selling live animals	72.0	18.0	10.0
Mean	*32.3*	*36.9*	*30.8*

In spite of the participation of men, women and youths in various farming operations, technology generation process has largely overlooked the specific roles being played especially by women and youths. The technical skills of women were often overlooked during technology development process because of inadequate gender disaggregated information and limited skills of gender mainstreaming. It has often

been perceived that women's major role is restricted to in and around the house, and thus classified as housekeeping service and not even considered as productive.

Estimation of workloads

Where women are involved in production, marketing, and product processing, such duties can take many hours a day—especially when, women have complete responsibility for in-house activities, crop production and management of animals kept near the homestead. Even though technology utilization can enhance the livelihoods of households, there are also cases that some technologies can exacerbate workloads of women, such as dairy technologies, which require intensive management practices, the roles mostly played by women.

The "T-Table" was used to determine workloads of women and. As illustrated in Table 7, during peak farming seasons, women spent 15 hours a day in executing both productive and in house activities. Out of this, they spent 27% of their time for farming while the remaining for domestic chores. On the other hand, men spent 11 hours for productive activities. It seems that men are not involved in domestic activities because of the fact that those responsibilities are traditionally defined to be women's only roles despite there are some improvements in men involvement. During slack period, the workload of women does not reduce significantly while it does for men because of engagement of women in various household activities.

Gender related problems

Regardless of increasing initiatives and extension works to aware the community about gender related issues, there is still significant cultural pressure. The fate of women's participation in public events is still at the hands of their spouses even though the change is undergoing gradually. Major problems facing women farmers include lack of knowledge, shortage of capital to start small businesses, land shortage, and limited access to improved seeds.

Similarly, the major problem of young girls is that they are not allowed to go out (in search of job) away from their parents. Due to this, they are solely dependent on family and have shortage of income to start small businesses of their own. Male youth are also constrained the most by lack of land, shortage of oxen, and shortage of inputs. Some of the youths are striving to engage in farming by renting in land from those who comparatively own large area of land. However, rental land is getting expensive and unaffordable by majority of the youth.

Table 7. Workload determination of women and men using T-table in Ambo District

Women		Men	
Activity	Time allocated	Time allocated	Activity
House cleaning	5:00-6:30 AM	6:00-7:00 Am	Supply feed to the livestock
Breakfast preparation	6:31-7:30	7:01-7:30	Hoeing maize in the garden, fence his house and garden
Breakfast time	7:31-8:30		Breakfast time
Milking cow, tending to livestock	8:31-9:30	8:31-1:00 PM	Farm activities
Hoeing	9:31-1:00 PM		
Lunch time	1:01-2:00		Lunch time
Fetching water	2:01-2:30	2:01-4:00	Farming activities
Back to hoeing	2:31-5:00	4:01-5:00	Giving drinking water for ox
Preparing dinner for the household	5:01-6:00	5:01-6:00	Animal herding and hoeing the farm
Breast feed baby	6:01-6:30	6:01-7:00	Feed the ox and rests
Milking cow/prepare coffee	6:31-7:30		
Clean miscellaneous kitchen materials	7:31-8:00		
Dinner time	8:01-9:00		Dinner time
Wash/clean baby/kid to bed	9:01-10:00	9:01	Bed time
Make ready food for tomorrow to the kids	10:01-12:00		
Go to bed	6:01		

3.2. Crop production

3.2.1 Features

The general agricultural feature is mainly characterized as traditional and subsistence type. The agricultural development support systems have great interest and objectives to change the traditional crop production system to a modern and productive system. Great effort is underway to identify alternative options to change the production system and provide appropriate solution on major crop production constraints. In the AGP-II woredas, the major crops grown include tef, wheat, barley, maize, sorghum, faba bean, field pea, chickpea, lentil, grass pea, noug, linseed, gomenzer, tomato, onion, garlic, cabbage, and potato. Among forage crops vetch and oats are grown very well.

In the North Shewa Zone, there is a problem of waterlogging, especially along with poor soil fertility while in lowland areas where sorghum is the main stay of the population, the problem of moisture stress is seriously affecting crop production. The farming community has great interest to use different agricultural technologies that are found appropriate in their farming system.

It is generally believed that the type of crop variety to be maintained for use is dictated by its filed level performance and yield potential. As a result, most farmers have developed an interest to use improved crop varieties but their wider use has been constrained by supply function. Though the use of improved varieties is increasing, in general, supply of improved seed is meager. Almost all farmers grow improved varieties due to their high productivity and market preferences. The major sources of improved seed are Bureau of Agriculture and natural resources (BoANR), the research system, private farmers and farmers themselves. Seeds from private producers are too expensive; for example, 1 kg of improved maize from private seed company is 35 birr). The other problem related to seed is its accessibility, equity and timely distribution. The farmers believe that grain yield is increasing in relation to input use but due to problems like diseases and insect pests, unavailability of improved seed, the increase in productivity is meager and also fluctuating. Some of the earlier crop varieties are becoming out of production due to diseases. For instance, the majority of wheat varieties are currently out of production due to rust problem and only two varieties, Digalu and Hidase are under production. The rust disease in some districts already hits even these varieties.

The old farmers' cultivars are disappearing or declining, such as composite maize, red wheat (*Qamadii Diimaa*), red tuber potato (*Oromo Dinich*), and red sorghum (*Zengada*) due to their low productivity. Crops that have recently been emerged due to intervention include quality protein maize (QPM), highland maize, malt barley, Kabuli chickpea, triticale, and oats. These crop varieties are preferred over the old ones due to their high yield, quality, market preference, or tolerance to stresses. Triticale is one of the most preferred crops because of its resistance to the major diseases and frost but it has threshing problem. Farmers in north Shewa called it "*Assaqaayyoo*", pertaining to its troubling nature in threshing.

3.2.2 Use of agricultural inputs

Improved seed: Most of the farmers know the importance of improved crop varieties. Some farmers mentioned that they use improved seeds of maize, wheat, and tef but complained that they could not get enough seed. For crops like barley and faba bean, they rarely get improved seeds. This clearly indicates that the use of improved seeds is low in general. The low use of improved seeds is mainly due to its unavailability. Moreover, the use of improved wheat seed is declining due to rust problem. Most of the improved varieties in the farmer's hands have already become susceptible to rust disease.

Fertilizer: The use of inorganic fertilizer illustrated an increasing trend though due to economic reasons farmers often use under dose as compared to the recommendations. These days, crop production is unthinkable without use of fertilizer. DAP and Urea are among the major inorganic fertilizers that have been in use. In recent years, the fertilizer (NPS) is being introduced and promoted. For instance, report from north Shewa BoANR indicated that 6,265 tons of NPS fertilizers have been distributed during 2014/2015. Application of inorganic fertilizer depends on the types of crops grown. Tef is the priority crop in receiving inorganic fertilizer followed by wheat and barley. The trend in the use of fertilizer is similar. All farmers apply fertilizers for major cereal crops like tef, wheat, barley and maize. Crops like linseed, red sorghum (*Zengada*) and field pea are the least recipients of fertilizer. Organic fertilizers are mostly applied to smaller plots of maize, faba bean and potato but not to wheat, tef or barley as these crops are grown on relatively larger plots of land which is difficult to cover with organic fertilizer. The limitation in this regard is the availability of compost to cover the large areas of farm plot and lack of standard quality compost preparation and appropriate use/ application in the field.

In general, it has been estimated that 85-90% of farmers use inorganic fertilizer while only 10-15% of farmers use organic fertilizers due to unavailability/alternative use, bulkiness, and inconvenience of application. According to the respondent farmers during the survey, model and well-to-do farmers afford to buy and apply fertilizer as per the recommendations while intermediate farmers could buy and apply fertilizer for cereals but mostly use under dose. On the other hand, resource poor farmers do not afford to buy and apply fertilizer at all unless they rent-out their land to rich farmers who could afford the purchase of fertilizer.

Application of fertilizer is not soil-test based; rather, it is still based on some old blanket recommendations. NPS fertilizer is getting acceptance because of its better performances over the traditional DAP and Urea formulation. At the beginning, there was big resistance against NPS, especially from the cooperatives, but this time it is no more a problem as the farmers are convinced through practice.

In recent years, the use of bio-fertilizer (inoculants) has been in an increasing trend for faba bean production. During 2014/2015 production season, for instance, 7702 sachets of bio fertilizer (inoculants) has been distributed and used in North Shewa Zone.

Farmers' decision, capability and options for use of production inputs often determine whether a farm business is profitable or not. More intensive and efficient use of production inputs such as improved seed, fertilizer and pest control chemicals are fundamental for sustainable crop production thereby meet national food security. But

extremely limited access to and use of improved seeds and fertilizers, irrigation, small-scale mechanization, and reliable sources of advice, credit, market information and other inputs are detrimental to smallholder agriculture in AGP-II districts as it is elsewhere in Ethiopia.

Pesticides: Farmers use pesticides for the control of weeds, diseases, and insects depending on the crops they grow and their purchasing power. Most farmers use 2-4-D to control broad leaf weeds and Green Star against grass weeds while few of them use non selective pre-emergence herbicide like Roundup. To control rust on wheat, a few farmers spray chemicals like Tilt. Very few farmers spray Mancozeb to control chocolate spot disease on faba bean and late blight disease on potato. Some insecticides such as Deltametrine, Durasan, Malathion and Endosulfan are also used for the control of insect pests such as aphids, stalk borer, and African ball worm. The source of pesticides is Adami Tulu Pesticide Formulation Factory.

Problems related with chemical use: The farmers go to the traders and ask for the chemicals that control their pests of concern, for instance, for control of wheat rust or insect or weed. The chemical traders, however, have no knowledge of crop pests as such but give the farmers the chemical they feel would control the pest upon their request. These chemicals are sometimes not effective in controlling the pests. There is no one who monitors and inspects whether that chemical is the right one for a given pest and its efficacy. The traders sell the same chemicals for use against different pests though the chemical is not multi-purpose. In addition, due to lack of knowledge, the farmers use these chemicals for the control of humans pest like lice, flea, and for curing itching on their skin.

Another problem related to chemical use is that the packaging of the chemical might be in one liter, the amount that is recommended for one ha of land, but the farmer wants to use on his smaller piece of land. So, farmers use some amount of the content of the package and keep the remaining. This leftover chemical at home is highly risky as there are reported cases where it was consumed by children and family members accidentally.

While the farmers use the chemicals to spray their fields, most often they do not use safety devices like gloves, mouth masks, etc. Since they do not see the immediate effect of the chemicals on their health, they think that these chemicals are safe without any protective devices. Sometimes the farmers clean their chemical wetted hands on soil or grass—without proper washing—and serve their meals. For the control of storage pests, farmers treat their seeds; for example, with high rate of the chemical. Sometimes they use these seeds for food before the chemicals are degraded and safe to

use the grain; farmers also take such seeds to the market for sell which is dangerous to consumers.

Therefore, stakeholders should exert concerted effort to raise awareness of the farmers on safety measures and proper use of chemicals. Trading of chemicals should also be done by specialists on chemical, not by anyone who could get the license without having knowledge of crop pests and chemicals.

In general, there is under-utilization of inputs and misuse of the chemicals by farmers. This has resulted in low productivity and production and health problems. The reasons for underutilization of the input are many and complex: high price of the input, low purchasing power of the farmers, unavailability of the inputs, low perception of the farmers about the importance of input utilization and inadequate extension service to aware the farmers on input utilization.

3.2.3 Challenges of crop production

Onion and garlic root rot and garlic rust: most farmers who grow onion and garlic complain about these diseases. A severe case of garlic rust, especially the one that appears early in the season, can reduce bulb development or kill an entire crop outright. Garlic and onion rot is a disease commonly called white rot and is a serious disease of plants of the allium family, especially bulb onions, garlic and leeks, caused by the soil-borne fungus *Stromatinia cepivora* (syn. *Sclerotium cepivorum*), which can persist in the soil for many years. It is a major disease complained about by most of the onion and garlic-growing farmers.

Increasing trend of potato diseases: Late blight of potato (*Phytophthora infestans)* is a fungal disease that causes serious yield loss. Last year (2016), due to favorable climatic condition for rust (temperature above 10°C and humidity over 75%), most farmers lost their crop. There are tolerant or resistant varieties that farmers grow with a few sprays of chemicals like Redomil and Mancozeb, but last year it was unable to control with a few sprays they used to do and a serious yield loss was inflicted.

Faba bean and field pea diseases: such as chocolate spot, rust and Aschochyta blight and recently occurring "faba bean gall" (ቆርጎምዲ). Chocolate spot, caused by Botrytis fabae is the most severe disease affecting faba bean. It occurs in all areas where faba bean is grown and causes losses ranging from minor to complete crop failure. Affected plants usually have fewer pods which reduces their yield potential. In unprotected crops, the disease could cause yield reduction of 30-50% in bad years. The most devastating and newly emerged disease on faba bean is faba bean gall. According to a

survey report (Hailu *et al*., 2014), the prevalence of this new disease ranged from 85.5 to 100% in AGP-II zones, such as north Shewa zone of Oromia region. Ascochyta blight, caused by Ascochyta pinodes (*Mycosphaerella pinodes*) is also an important disease of field pea. It occurs in almost every field each year, and is capable of causing substantial loss in grain yield when epidemics develop early.

Susceptibility of improved wheat varieties to rust: due to break down of resistance gene. Fusarium head blight is also major wheat disease. Wheat rust is very severe. F*usarium head blight* is also becoming serious wheat disease. Most of the improved varieties have already became susceptible to wheat rust while only some varieties called Alidoro and Danda'a are somehow relatively tolerant to this disease. Consequently, shortage of resistant or tolerant varieties to rust disease of wheat was reported.

Threat of sorghum disease: especially a disease locally called "*Aynewuha*" and stalk borer are causing serious problem. "*Aynewuha*" is described as a disease that is associated with rain—if it rains in May, the disease appears in October. It usually affects crop sown late in July. Infected plants fail to produce seeds, resulting in tremendous yield loss; especially in the lowland areas. The disease described by the farmers is assumed to be ergot with the common name 'sugary disease' that is caused by *Claviceps africana*. But this requires further identification and confirmation by Pathologists as soon as possible.

Aphids and African bollworm: These pests attack on field pea and grass pea is increasing. In 2016, aphids devastated almost all grass pea fields resulting in great yield loss. Control of the problem has been very challenging even with chemical pesticides. Pea aphids are serious threat to field pea production. Due to the insect pest, field pea production is becoming abandoned by many farmers. Unless effective control measures are set in place with immediate actions, field pea will be out of production within a few years.

Other diseases and pests: the occurrence and expansion of new grass weed that could not be controlled by the existing chemicals. Since it is also difficult to pull out by hand, it is becoming another threat to cereal crop production. In the lowland areas where sorghum production is important, striga weed and bird (Q*uella quelea)* damage are becoming more serious problems in recent years than ever before.

Inefficiency of supply and delivery of inputs: In adequate improved seeds supply along with unaffordable prices is evident. The supply of improved seed is almost entirely done through agricultural bureau despite not enough to satisfy the current demand. The demand for improved seed is largely covered by the informal seed

supply system, which is the largest source of seed. In this regard, farmers practice informal seed supply and exchange. In addition, there is shortage of feeds and fodder; the lack of appropriate and proven pesticides for the control of crop diseases, pests, and weeds; unavailability of supply of protective devices during pesticides application; and lack of small packed inputs for small plot of smallholder farmers.

3.2.4 Effects of climate

Farmers perceive climate change/ variability by the following indicators

- Increasing trend of temperature that results in increasing trend of insects pests and diseases;
- Erratic rainfall that is expressed in terms of late on set and early cessation; for example, in 2017 the "*Arfasa*" rain for sorghum and maize planting was late;
- Declining trend of number of animals, partly due to shortage of grazing land;
- Declining of underground water and natural springs; and
- Expanding trend of goats from *kolla* to *woyna dega* and horses to more highland areas are assumed by the farmers as indicators of climate change.

Normal rainfall scenario for favorable growth of crops as described by the farmers include the following: First shower of rain in March and continue until April that helps for first plowing of the land; dry spell in the month of May to kill weeds that germinate by the previous rainfall; restarting of rainfall from mid-June to start planting of crops that continue until September; rain stop in September for a while and some shower in October. Deviation from this trend, especially cessation of the rainfall during grain filling period of the crops is among the indicators of climate variability. Other indicators of climate change farmers perceived are poor forage establishment for animal grazing, shortage of drinking water and dry up of water sources and natural springs. There is a shift in insect pest and disease occurrences, for example, field pea and grass pea bollworm occurrence in the last season; Farmers believe that this is unusual and might have occurred due to climate change. Farmers also considered the unusual frost occurrence as an indicator of climate change. Occurrence of frost used to be known in the month of October. However, recent trends show that frost period extended to the months of November and December. Occurrences of frost coupled with moisture stress exacerbate the adverse effects on crop production.

Some coping mechanisms of climate change by smallholder farmers include:

- Soil and water conservation strategies such as rainwater harvest;
- Use of early maturing crop varieties like "*Bira'e* and *Samareta*" local barley cultivars or any other improved early cultivars, noug, linseed, tef (*Kuncho*), wheat (*Dende'a, Dekeba,*

Hidase, haricot bean, planting fruit trees etc. In maize, farmers are tending to grow early maturing maize varieties like BH 540 than BH660;

- Growing of cash crops like vegetables (e.g., garlic, onion, cabbage) that are early maturing and grown to generate income;
- Using full-package of technologies;
- Adopting conservation agriculture (climate smart agriculture);
- Planting of multi-purpose tree species that could be used as fodder for animals, improve soil fertility and also fruit trees that could help in soil conservation; and
- Engagements in off-farm income generating activities as options of livelihoods during crop failure.

3.2.5 Emerging issues in the farming systems

Frost occurrence this year during crop maturity season was a new phenomenon. Most crops were affected with the consequent tremendous yield loss. Termite problem is increasing from time to time. It occurs in crop fields, homesteads, and in the house. It piles heap of soil or mounds in places it occurred. It affects crops such as tef, wheat, and barley.

Wheat rust and foot rot, though it is there for long, its incidence and severity is increasing from time to time and almost all improved cultivars are becoming susceptible. Diseases like chocolate spot on faba bean are there for long and yet no resistant varieties generated. There is a new type of aggressive bollworm like insect on grass pea, which is has not been there before. Last crop season, almost all farmers lost their grass pea crop for this pest. There are some grass weeds that are becoming dominant and problematic in cereal fields. They are not killed by herbicides or easy to pull out by hand. Fall armyworm is also becoming a threat in recent years.

3.2.6 Storage structures

Most of the farmers (more than 85%) use local sacks, that is, polyethylene bag to store their grain while an estimated proportion of about 10% use grainer "*Gotera*" and the rest use earthen-made container (*Dibignit*). No farmer uses the modern containers like *PICS* Bags, Supper Bags, Hermetic Bags, or Metal Silo. These containers are airproof and believed to control storage insects by limiting oxygen in the bags.

3.2.7 Trends in crop productivity

Crop productivity is fluctuating due to a number of factors: erratic rainfall, pests, and diseases occurrences. There is increment of productivity over long period of time as input usage is increasing but this increase is countered by those yield reducing factors like terminal moisture stress, newly emerging diseases and insect pests which are

changing over time. In response to the recognition of the importance of improved agricultural technologies, an increasing trend of improved technologies demand and utilization has been observed over time. However, the increasing trend has not reached the highest alternative scenario due to different production constrains described above. For instance the highest productivity scenario for tef is 4.0 t/ha and for wheat 8.0 t/ha but the achievable yields were 2.1 t/ha for tef and 4.6 t/ha for wheat by model farmers.

3.3. Livestock production

3.3.1. The resource base

Livestock production is an integral component of the agricultural system. Livestock play different economic and social roles to smallholder farmers, *viz.*, as sources of income, food, fuel, draught power, manure and as measures of wealth as well as social status. As a case analysis, the livestock resource bases of Ambo and Grar Jarso districts are presented in Tables 8 and 9, respectively. As shown in Table 8, cattle are the dominant ruminant livestock species reared followed by sheep and goats. More than 98.5% of the cattle population in Ambo District belongs to indigenous breeds indicating that market oriented livestock production—mainly dairying—is not developed in the area. Moreover, the cattle herd at Ambo District is very closely dominated by cows and oxen followed by replacement heifers and bull calves. The farmers' major aim for keeping cattle is to secure adequate draught oxen for farming and they also give equal emphasis to cows and heifers for the production of replacement oxen. Fattening using oxen towards the end of their service time and also sheep and goats is commonly practiced as an income generating activity in the area. However, the fattening operations are not adequately supported by improved technologies and mostly conducted following the farmers traditional management practices. Even though case analysis has been drawn from Ambo District, the status of livestock production is similar in other districts as well.

Horses, donkeys, and chicken are the other livestock species reared in the area. Moreover, beekeeping mainly using traditional beehives is practiced to generate additional income to farmers.

The second case analysis was also taken from Grar Jarso (Table 9). Cattle are still the dominant ruminant livestock species reared in this area alike the case in most mixed farming systems of Ethiopia. Cattle with exotic genetic inheritance account for 32% of the total cattle indicating the high dairy potential of the area. Moreover, close to 46% of the calves and 38% of heifers are of improved types showing the tendency for shifting to keep more of improved cattle breeds. This is in line with previous findings that showed that about 70% of farmers in North Shewa have adopted improved dairy

technologies (Agajie *et al.*, 2016). Oxen are the second dominant cattle herd followed by replacement heifers, calves and bull calves in the area.

Small ruminants, chicken, and equines are also the important livestock species reared at Girar-Jarso. Some farmers in the district also practice beekeeping as an additional income generating activity. In general, livestock ownership in Grar Jarso can represent the status in other districts of the Zone as well.

Table 8. Population of different livestock species in Ambo district during 2016/17

Livestock	Indigenous	Improved/crossbred	Total
Cattle	151420	2200	153620
• Cows	41427	1100	42527
• Draught oxen	39197	-	39197
• Bull calves	26800	100	26900
• Heifers	28975	300	29275
• Calves	15021	700	15721
Sheep	68887	-	68887
Goats	31537	-	31537
Equines	35506	-	35506
• Horse	17801	-	17801
• Donkey	17060	-	17060
• Mule	645	-	645
Chicken	-	-	92030
Beehives	-	-	9542
• Traditional	-	-	9021
• Transitional	-	-	158
• Modern	-	-	363

*Source: - Ambo District Livestock and Fisheries Development Offi*ce

3.3.2. Feed resources

The study showed that crop residues followed by natural pasture grazing constitute the major sources of livestock feed. The information obtained from Ambo District Agricultural Development Office showed that about 74.4% of the total land area of the district is devoted to crop production while grazing land accounts for only 8,370 ha (10%) of the total land (Figure 2). According to the livestock statistics obtained from the District Livestock and Fisheries Development Office, there were 289,550 heads— about 144,000 TLU—of larger ruminant and non-ruminant livestock in the district. Provided that the aforementioned grazing land is fully accessible to all grazing and browsing livestock, 1 ha of grazing land is expected to support 35 heads of animals.

Table 9. Livestock population in Girar Jarso District during 2016/17

Livestock	Indigenous	Improved/crossbred	Total
	107550	51217	158767
• Cows	31640	10140	41780
• Draught oxen	29996	8290	38286
• Bull calves	9489	6826	16315
• Heifers	20646	12560	33206
• Calves	15779	13401	29180
Sheep	59180	-	59180
Goats	20991	-	20991
Equines	26783	-	26783
• Horse	3168	-	3168
• Donkey	23098	-	23098
• Mule	517	-	517
Chicken	70682	15244	85926
Beehives	-	-	5233
• Traditional	-	-	3506
• Transitional	-	-	892
• Modern	-	-	835

*Source: - Girar Jarso District Livestock and Fisheries Development Offi*ce

The normal average year round carrying capacity of a protected native pasture is 2– 3 TLU per ha (Lulseged, 1985). Under traditional systems, grazing lands in AGP-II districts usually represent fragmented areas unsuited for crop production due to various physical and topographical limitations—swampy/water logged and/or areas with rugged terrains, degraded lands and roadsides. Such lands are characterized by poor productivity and their average annual herbage yield under continuous grazing does not exceed 1 t DM/ha. Besides poor productivity, such grazing lands have limited accessibility for efficient utilization and the accessible parts are overstocked beyond their optimum carrying capacity leading to land degradation. This scenario clearly shows that grazing land as source of livestock feed has very limited prospect in mixed crop-livestock farming systems leading to heavy reliance of animals on inherently low quality crop residues as major feed resource. Tef, wheat, barley, maize, sorghum, faba bean, field pea, chickpea, and lathyrus residues are the major crop residues available for livestock feeding.

Besides the conventional feed resources, the farmers also reported to use atela—a by-product of the local alcoholic beverage (*tella and katikala)*—for selected groups of animals like milking cows. Moreover, seasonal use of purchased feeds—oilseed cakes mainly linseed cake and wheat bran—is also common by those farmers who fatten cattle and small ruminants. The surveyed farmers reported to have much preference to linseed cake for fattening purpose. One tricky aspect raised by the farmers in this

regard was that though they are the source of the intact linseed grain, there are cases where they purchase linseed cake at higher prices than the selling price of the grain. As a result, the farmers have demanded for a possibility of establishing small-scale oil processing plants in their vicinity so that they could be able to make efficient use of their produce. About 60% of the farm households practice fattening. Fattening is practiced for three to five rounds per year targeting the major national and religious festivals to make use of better market opportunities.

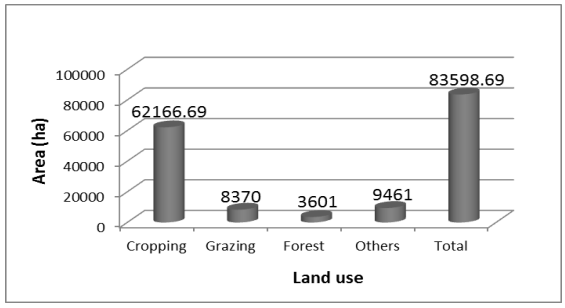

Figure 2. Land use pattern in Ambo District
Source: - Ambo District Agricultural Development Office

In general, an increase in population and lack of access to land by the emerging youth have led to expansion of cropping into every piece of available land imposing a major limitation on feed availability and livestock production in the mixed farming systems. The increase in human population will also be followed by a corresponding increase in cattle population in order to secure adequate oxen supply for farm power.

Different categories of feed resources were also reported to be available for livestock feeding at Grar Jarso where dairy is an important commodity. The dominant feed resources used for feeding dairy cattle include natural pasture hay, crop residues, pasture grazing and some improved forage crops like oats/vetch and backyard grown fodder trees such as tree lucerne.

Hay making from seasonally rested pasture land is also commonly practiced in the some households on own holding and/or by contracting standing hay from other farmers. Prices for contracting standing hay are negotiated based on land area and visually assessed stand performance of the pasture. The contacted farmers and key informants in the case analysis of Grar Jarso; for example, have reported that a quarter hectare of pasture land was contracted for 4000–5000 Birr for hay making in a season. Previous studies in selected dairy shed areas in Girar-Jarso, Sululta and Ejere have also reported that close to 50% of dairy farmers produce natural pasture hay on their own holding ranging in area from 0.1-1.50 ha per household (Fekede, 2013). The

same study also reported average dry matter (DM) productivity of seasonally rested pasture to be 7.97, 5.63 and 6.04 t/ha at Girar-Jarso, Sululta and Ejere, respectively. According to discussions with district level experts, development agents (DAs) and farmers, the farm gate price of a bale of natural pasture hay (~16 kg) ranged from a minimum of 50 Birr during harvesting season to a maximum of 100 Birr during the peak dry season. This corresponds to 3 to 6 Birr per kg of hay, which is comparable to or sometimes higher that the price of wheat bran. Table 10 below indicates that hay is a highly valued commodity which can generate an average gross income of 37,350 Birr—ranging from 24,900 to 49800 Birr—per hectare from seasonally protected and well managed pasture in Girar-Jarso.

Table 10. Average productivity and estimated monetary value of natural pasture hay

Parameter	Estimate
Productivity (t DM/ha)	7.97
Estimated quantity of hay bales that can be produced per ha (1 bale ~ 16 kg)	498
Price per bale (Birr)	75
Gross income (Birr/ha)	37,350

Source: Fekede, 2013

Use of green oats for cut-and-carry feeding and marketing for the same purpose is also commonly practiced in high potential dairy production areas of the district. At Girar-Jarso, one donkey load of green oats—an estimated 80-100 kg; 20-25 kg on dry matter basis—costs about 350 Birr. This implies that 1 kg of oats estimated on DM basis costs at least 14 Birr, which is much expensive than any other feed ingredients on the market including concentrates. A well-managed oats can produce at least 8 t DM/ha—about 32 tone fresh feed—under farmers` field. From this, one can imagine how much income can be generated from a hectare of oats field indicating that oats can be potentially considered as an important cash commodity. Hence, growing and using oats along with improved dairying is much worthy in Girar-Jarso and other similar areas. Hay making using oats/vetch mixture was also reported to be practiced by a few farmers while most farmers attested that they do not practice mixed cropping of oats and vetch due to mismatch in sowing time of oats and vetch. According to the farmers, oats is sown in May while vetch and other legumes such as lathyrus and chickpea are grown using residual moisture in September.

Different agro-industrial by-products mainly wheat bran, noug seedcake, and molasses and local beverage residues are also commonly used for feeding dairy cattle and fattening animals. In the less potential lowlands such as Grar Jarso, feed shortage is quite alarming due to critical shortage of land, land degradation and the consequent scarce biomass cover. In these areas, livestock production is mainly subsistent and

crop residues—dominantly sorghum stover and tef straw—constitute the major sources of livestock feed.

Despite the high suitability of districts like Grar Jarso, Ambo and Woliso, for livestock production in general and dairy production in particular, utilization pattern of the available land is still highly in favor of crop production (Figure 3). For instance, in Grar Jarso, pastureland accounts for 16% (7909.6 ha) of the total land area of the district (49435 ha) while 75% of the total land is used for crop production.

Based on the 2016/17 livestock statistics obtained from Girar Jarso Livestock and Fisheries Development Office, there are 265,721 heads (an estimated 130,229 TLUs) of ruminant animals and equines. Provided that the aforementioned grazing land is fully accessible to all grazing and browsing livestock, 1 ha of grazing land is expected to support about 34 heads of animals (~16.5 TLUs) which is more than five-fold of the recommended year round carrying capacity of a protected native pasture (2 – 3 TLU) per ha (Lulseged, 1985).

Alike the case in other crop-livestock mixed farming systems, grazing land as source of livestock feed has a very limited prospect in Girar-Jarso, and other similar areas unless binding policy measures are taken to delineate a fair share of grazing land to ensure sustainability of both crop and livestock production in the country. The other way out will be intensification of livestock production by keeping a few productive animals using mainly farm grown forages and other supplementary feeds, with a minimum/controlled grazing. However, this may not be materialized in the near future as the main purpose of keeping cattle by farmers is to secure adequate supply of draught oxen for farming. In order to secure a pair of oxen, a farmer is always opting to keep 3–4 female cattle which necessitate keeping 5-6 cattle per household. If the main purpose of keeping cattle is to produce milk, one or two productive/crossbred cows could be sufficient per household in which intensification may be possible. Therefore, possible introduction of mechanization in applicable areas can potentially help to reduce dependency of crop agriculture on animal power and thereby paves a way to improve productivity of the livestock sector. Moreover, areas which have comparative suitability to livestock production in North Shewa, should be focused for a targeted development intervention and extension services gearing towards livestock/dairy production.

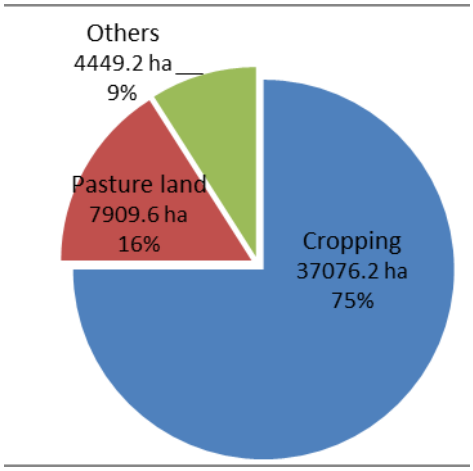

Figure 3. Land use pattern in Girar-Jarso District

Source: - Girar-Jarso District Agricultural Development Office

3.3.3. Animal health management

Prevalence of various livestock diseases and parasites was reported to be among the major limiting factors to livestock production (Table 11). Pasteurelosis, blackleg, foot and mouth disease (FMD), and Anthrax were recognized to be the major diseases affecting cattle in the study areas. Moreover, mastitis and milk fever are common problems reported in cattle especially in North Shewa zone due to concentration of high producing and susceptible dairy cows in the area. The most common parasitic disease affecting cattle and sheep was liver fluke. Grazing on waterlogged areas is the major factor, which predisposes the animals to the parasite. Leech and tick were the other most dangerous parasites affecting cattle mainly during the dry season. During the dry season, the available running water resources get dry and animals depend on stagnant waters where Leeches accumulate and infect the animal during drinking. The Leeches first attach themselves under the tongue and if remain unnoticed and not removed timely, they migrate to other organs such as the brain and digestive system leading to further complications and animal death.

Veterinary clinics are available to render animal health care services. However, most of them are located in and around urban centers and less accessible to majority of farmers inhabiting the rural areas—more than 5 km away. Moreover, even those farmers who have access to veterinary clinics complain that they usually do not get the required drugs from the public veterinary clinics and forced to purchase drugs from private shops for high prices but less efficient in healing their animals. Farmers in Selale have reported to have comparatively better access to veterinary clinics and animal health services than the case in West and Southwest Shewa Zones. This might

be attributed to the cumulative effects of different dairy development projects implemented in North Shewa Zone.

Table 11. Important livestock diseases and parasites

Livestock	Infectious diseases	Parasitic diseases
Cattle	• Pasteurelosis • Blackleg • Foot and Mouth Disease (FMD) • Anthrax • Lumpy Skin Disease • Bovine Tuberculosis • Mastitis • Milk fever • Stretothricoccus	• Liver fluke • Leech • Ticks • Lice
Sheep and goats	• Sheep pox • Pasteurelosis • PPR (Peste des Petits ruminants) • FMD	• Liver fluke • Ticks • Lice • Mange-mites
Chicken	• Newcastle Disease (NCD) • Coccidiosis • Gumboro • Fowl typhoid	
Horses	• African Horse Sickness (AHS) • Lymphangitis	
Honey bees	• Wax mouth	

3.3.4. Livestock Technologies

The status of utilization of available livestock technologies was also assessed in the study areas. The findings showed that improved dairy technologies are well adapted and in use especially in North Shewa Zone, in general, and in Girar-Jarso District, in particular. This has been due to the combined efforts of research, i.e., crossbreeding and demonstration and different dairy development projects that have been launched beginning from the early 1970s. The major components of the dairy development projects included introduction of crossbred dairy heifers, provisions and strengthening of AI and/or bull services, animal health services, improved fodder development, improvement of locally available feed resources and facilitations of the dairy marketing systems.

These interventions coupled with suitability of the area for dairying have resulted in better adoption of dairy technologies with the consequent high concentration of improved dairy cows and high milk production. According to the livestock statistics obtained from Girar-Jarso District Livestock and Fisheries Development Office, cattle

with exotic genetic inheritance account for about 32% of the total cattle population available in the district. Moreover, 113 thousand liters of milk was daily produced from crossbred cows alone in North Shewa Zone, of which 75%—more than 80 thousand liters per day—was collected from Grar Jarso District alone and channeled to the market. When the milk produced and marketed from other potential districts of the Zone is added to this, North Shewa is substantially contributing to milk supply for urban consumers especially in Addis Ababa. Previous studies have also shown that over 70% of farmers in North Shewa zone have adopted crossbred dairy cows (Agajie *et al.*, 2016).

On the other hand, adoption of improved dairy technologies was reported to be lower in West and Southwest Shewa Zones. For instance, according to the sources from the Ambo District Livestock and Fisheries Development Office, there are only about 2200 improved dairy cattle—accounting for 1.43% of the total cattle—in the district. Some individuals in and around Ambo Town have crossbred heifers. According to livestock production experts and farmers who participated in this study, efforts made to improve the farmers` cattle through estrus synchronization and AI has not been successful to the expected level. Moreover, improved dairy technologies have not been adequately demonstrated and popularized to smallholder farmers even near the town. As a result, milk supply is reported to be very insignificant despite the huge demand for milk and other dairy products in urban centers. During this study (2017), a liter of milk was sold for 16 – 18 Birr in some nearby towns such as Ambo, which is quite unaffordable by majority of the consumers. Use of other associated technologies such as improved forages, improvement of crop residues, supplementations, and applications of proper feeding management are also practiced at a very limited scale.

Other livestock technologies such as improved chicken breeds were also reported to be introduced and adopted by a few farmers.

3.3.5 Livestock production and food/ nutrition security

Livestock have both direct and indirect contribution to food and nutritional security. The direct and indirect roles of livestock to food and nutritional security of the farm households in the study areas are described below:

Provision of animal source food (ASF): Livestock produce and provide a regular supply of nutrient-rich ASF which helps to supplement and diversify the staple crop based diets of the smallholder farmers. Milk and milk products, and eggs are mainly the important livestock products used to complement the food value and/or mitigate seasonal fluctuations in grain availability particularly of pulse crops (Randolph *et al.*, 2007).

Household level utilization of different livestock products are presented in subsequent sections. According to case analysis in Ambo District, an estimated 40% of the total milk produced in a household was reported to be directly consumed, while the rest 60% was processed into butter and cheese. Direct selling of milk by the smallholder farmers was uncommon, as dairy production in the district has been mainly based on low producing local cows, except the case of few producers in and around Ambo Town who own crossbred cows and supply milk to the market. An estimated 46% of the butter produced per household was consumed at home while the remaining 54% was sold to generate income. Similarly, 64% of the cheese produced per household was used for home consumption, while the rest 36% was sold. According to the surveyed households in Ambo, eggs are mainly consumed by the family and only small proportion is sold. The study showed that the farm households had no regular access to consumption of meat as slaughtering of animals for meat only occurs during exceptional occasions like national and religious festivals, and cultural ceremonies such as marriage. Hence, meat consumption is limited to these special occasions. It was generally found out that the production and supply of livestock products in most areas was basically subsistent and not market-oriented.

According to the case analysis findings in Girar-Jarso, 12% of the milk produced was reported to be directly consumed at home, 13% was processed into butter and cheese mainly for home consumption while the remaining majority (75%) was reported to be sold. According to the Girar-Jarso District livestock production experts, more than 60% of farm households in the high potential areas of the district—those located within 5 km radius from Fiche Town—own at least 1-2 crossbred cows. Considering an average daily milk yield of 10 liters per cow, an estimated 1.2 liter (12%) could be used for direct consumption by the family (6 persons on average). In addition, cheese and butter generated from the processed milk (13%) are mainly used for family consumption although some amount is also sold. Based on this assessment, majority of the farm households in the high potential areas of the district have better access to consumption of milk and milk products, which is essential to improve the nutritional status of the society. Moreover, high amount of milk—more than 80 thousand liters per day—is collected from the district and channeled to the market substantially contributing to food and nutritional security of urban consumers, such as those living in the city of Addis Ababa. About 27% of the eggs produced per household were consumed at home while the rest 73% were sold to generate income at Girar-Jarso district.

In general, securing a regular supply of ASF in the diet is highly essential to improve nutritional status thereby build a healthy and productive society. Hence, introduction

and popularization of improved livestock technologies mainly in West and Southwest Shewa zones is required to improve animal productivity and ensure adequate supply of ASF.

Source of income: Livestock and livestock products serve as routine sources of income to smallholder farmers in the study areas. For instance, the households in Ambo District have reported that 50 to 60% of their annual income is generated from livestock. Households in Girar-Jarso District have also reported to generate more than 70% of their annual income from livestock mainly from sell of milk. In peri-urban and urban areas, a farmer owning two milking cows can generate at least 6000 Birr per month from sell of milk. Assuming about 60% of this income may be spent for feed—mainly supplementary feed—and animal health care, then the farmer can secure a net income of about 2400 Birr per month, which is equivalent to 28,800 per year from milk alone. This could be further increased when income from milk products such as cheese and butter and dung cake is added. Moreover, the farmers generate high amount of income by selling dairy heifers ranging from ETB 20,000 for a heifer at or close to puberty stage to ETB 40,000 for a pregnant heifer/cow. Farmers sell improved heifers in cases such as when the herd size increases beyond their resource/management capacity, to purchase grain in cases of crop failure and/or when they seek additional business opportunity. Expenditures related to all farm inputs, schooling, medical, and other household expenses are covered using the income from sale of livestock and milk in North Shewa. However, in West and Southwest Shewa Zones, farmers generate more income from fattening cattle and small ruminants.

Source of draught power: According to the contacted district experts and farmers, the purpose of rearing cattle by majority of subsistent smallholders under the rural setting is primarily to secure oxen supply for farming. A household with an average landholding of 1-2 ha should own at least a pair of oxen, which necessitates keeping 2-4 cows to produce replacement oxen. Moreover, equines play a significant role for transporting goods to-and-from market and agricultural produce from field to home which helps to reduce the workload imposed on women. In general, the entire farm operations pertaining to crop cultivation is performed by animal power indicating the crucial role of livestock in food and nutritional security.

Producing manure*:* Livestock waste is used as an important source of organic fertilizer for maintaining soil fertility, and hence contributes to increased crop production for food and income in crop-livestock mixed farming systems. It was reported that compost preparation using animal waste is practiced by considerable proportion of farmers mainly in West and South West Shewa Zones enabling them to save a portion of expense required for inorganic fertilizers. Use of cow dung for fuel and building

material is also common. For instance, preparation of cow dung cakes for use as source of fuel and/or sale for income is commonly practiced by dairy farmers. For instance in Girar-Jarso district, about 100 pieces of dung cake for fuel generate an income ranging from ETB 50–100, and if a household produces about five piles of dung cake, it can generate ETB 250–500 in a season, an income which is adequate to cover educational materials for 1–2 students in rural areas. This income can be raised during the rainy season.

Livestock serve as financial stocks: Most smallholder farmers either do not have access to standard financial institutions such as banks or do not have a culture of going to banks for saving. Instead, they use livestock as an alternative for storing their savings or accumulated capital as a "living savings account" which can be sold and changed into cash when needed and provide an instrument of liquidity and consumption smoothing. Farmers generally consider keeping livestock as an alternative form of insurance, providing the family with assets that can be sold in times of crises.

Livestock as an indicator of social status: Farmers associate higher social status with access to or authority over a broader base of resources in the community. In this regard, farmers either mainly in the rural setting place considerable value on livestock as an indicator of social importance within the community, based on the size of a family's livestock holdings, or in their sharing of livestock with others to strengthen social bonds, including the use of livestock as dowry or bride price.

3.3.6. Livestock production and climate change

Livestock production experts and households were requested how they perceive climate change/variability and its effect on livestock production and the overall agricultural activity in the area. Accordingly, most of the respondents have attested that the weather pattern has undergone dramatic shift in recent times imposing major limitations on both livestock and crop production. Rainfall is the most uncertain and fluctuating climatic variable often characterized by late onset and early withdrawal resulting in prolonged dry season. According to the households, the short season rain or locally called "belg rain" has shown drastically declining trend over the last 15 years and totally missing and/or insufficient to support crop and pasture growth nowadays. Seasonally sever frost, storm and hail damage are also the other recurring weather phenomenon affecting both crops and livestock in the study areas.

Such a change in weather pattern has a direct consequence on livestock production by affecting the availability and quality of feed and water as well as by pre-disposing the animals to various diseases and parasites. For instance, livestock are heavily infested with leech during the dry season due to shortage of drinking water and dependence of

animals on stagnant and unclean water resources that harbor a lot of leech. This in turn pre-disposes the animals to other different diseases. In general, climatic variability not only affects animal productivity and supply of livestock products, but also limits the draft power output required for crop production thereby affecting the overall agricultural productivity and farmers` livelihoods.

3.4 Natural resources management

Natural resource management (NRM) is an interdisciplinary field, which deals with the physical, biological, economic, and social aspects of handling natural resources. It involves putting resources to their best use for human purposes in addition to preserving natural systems. The assessment has figured out various perspectives of NRM as presented in subsequent sections.

3.4.1 Land resource management and related issues

According to the findings of this survey, land holding per household has revealed a decreasing trend since the last two decades. There is land redistribution among family members in that parents are responsible to share land to their sons when they reach the age of marriage to establish their own life. Thus, the fragmentation of land size per household has been a continuous process in the rural communities. Besides, areas with steep topography have been used for agricultural production. In the farming system, livestock number is also declining per household due to diminishing size of communal grazing land. At present forest land does not exist in the highland areas. Both problems were caused by expansion of crop land and urbanization. One of the newly emerging practices by farmers is use of herbicides to eliminate bushy weeds, which is then used for crop production. The deforestation and degradation of land also caused the extinction of indigenous tree species such as *Hagenia Absyssnica, Cordia africana, Prunus africana, Erica arbora, Coroton macckostachys, Acacia spp, Albizia spp, Olea africana* and a lot others, which are being replaced by *Eucalyptus spp.*

According to the experts and farmers in Ambo woreda, there exist bylaws developed by farmers in all type of land management practices and a committee who can implement the bylaws. But, currently, implementing the bylaws and acting on irregularities conducted by individuals or groups has been impossible due to the limited capability and strength of the committee.

3.4.2 Soil fertility management

It has been reported that agricultural productivity is declining because of the loss of top soil and deterioration of soil fertility. Soil erosion, depletion of soil organic matter and continuous cultivation are among the major factors responsible for loss of soil

fertility in the study areas. In response to this, farmers use various options to ameliorate soil fertility and improve crop productivity, such as inorganic and organic fertilizers, and crop rotation practices. For instance, most of the farmers commonly use in organic fertilizers, such as urea and di-ammonium phosphate (DAP) as sources of nitrogen and phosphorus, respectively. Because of high price of these inputs, farmers apply mainly for the production of cereals. Other fertilizer types (NPS) have also been recently introduced in most areas although it has not yet been adequately disseminated. The problem noticed was, however, that most of the farmers do not apply fertilizers based on soil fertility level and requirement of crops because of which application rates were suboptimal in most cases and crop yields are low. The productive capacity of each soil type is not also well known and documented. It was for this reason that soil test crop response based fertilizer research was conducted to determine the right types and rate of fertilizers. However, agricultural experts revealed that the newly developed soil test based fertilizer application map was not yet acquired.

The other option farmers use to improve and maintain soil fertility is rotation of cereals with pulses and oil crops. Some farmers also apply organic fertilizers, such as compost, mainly on fields around homesteads. Crop residues, green wastes, farmyard manure (FYM) and ash are the main organic sources for compost preparation. Pit is the commonest method used for compost preparation. Use of manure is also another option practiced by farmers although farms far away from the homesteads are not often amended with organic fertilizers owing to lack of transport and labor. However, use of cow-dung manure as a source of energy, and crop residues as livestock feed has hampered the application of these organic sources for replenishing soil fertility. According to farmers' estimation, cow-dung cake and wood contributes 70% and 30% of energy source, respectively. To apply cow-dung and crop residues to the soil, the farmers would be provided with options of energy sources, such as energy saving stoves. However, the supply of energy saving stoves was reported to be very limited.

The other technology that has been introduced to districts to improve the fertility of soils was vermi-compost although it has not yet been used by many of the farmers. The extension experts in some of the districts have also mentioned that vermi-compost has not been adequately disseminated to beneficiary farmers.

3.4.3 Soil and water conservation

The findings indicate that two types of soil and water conservation practices are adopted which include farmers indigenous knowledge (traditional approach), and community-based participatory watershed development (modern approach).

In the traditional approach, the local community protects farmland by constructing cutoff or diversion drains (channels) and planting trees on the farmland in erosion vulnerable places. For example, in Ambo District, soil and water conservation measures had been planned to start on 10 micro watersheds. All 10 watersheds were delineated and characterized as well as all the basic information has been documented. But implementation of integrated soil and water management was launched only on five of the micro-watersheds up to now. The five micro-watersheds performance was evaluated 'good' by the experts. In addition to the government mass mobilization of integrated watershed management program, there also exists a sustainable land management (SLM) project which has shown better success than other initiatives. The experts believed that the SLM project has sufficiently fulfilled the gaps that were not well undertaken by other projects due to the following gaps

- Absence of community watershed team/committee, and planning team;
- Disregarding problem identification and prioritization;
- Limited input provision to farmers, for example, seedling, and hand tools; and
- Lack of strong bylaw formulation and implementation

Men and women farmers were participating in the construction of soil and water conservation bunds, which is undertaken by government mass mobilization program. For instance, it was estimated that 75% of men participated in soil and water conservation initiatives while this proportion was estimated to be 25% for women. Farmers' participation was also reported in gully treatment using gabions and biological methods, i.e. planting grasses and multipurpose trees. Community participation in soils and water conservation (SWC) work is a continuous process every year. According to the information obtained from farmers, soil erosion was minimized and discharge of springs showed significant improvement due to implementation of the SWC practices. In the highland areas such as Ambo district, the participation of farmers in SWC work is 40% for men, 25% for women, and 35% for youth (21% for boys and 14% for girls).

According to AGP-I report for 2012 to 2015, gully rehabilitation was one of the initiatives that went very well. To scale out the successes and best practices of this initiative, it was also demonstrated to many of the farmers in AGP I beneficiary districts. For instance, 1754 farmers in Ambo district have participated in farmer demonstration programs, out of which 69% were men farmers, 12% women, and 19% youths. Consequently, it was also reported that 3344 farmers adopted gully stabilization technology during the 2012-15 period, out of which 65%, 15%, and 20% were men, women, and youth, respectively. The report has also mentioned that four micro-watersheds that covered 784 ha of communal land and 336 ha of farmland were

established during AGP I period. Therefore, this initiative needs to be scaled out during AGP-II period as well embracing more farmers and covering a large area of land.

It was also reported that soils are highly eroded because of continuous cultivation, complete removal of crop residues, removal of vegetation cover and poor land-use system. Although there is a land-use policy at federal and regional levels, it has not been yet implemented at local levels, where natural resource degradation is rampant. What is relatively special especially at lowland areas, such as Girar Jarso, is that farmers are well aware of the significance of soil and water conservation practices. This is because, the conservation structures, particularly the physical conservation measures have been practiced for over three decades. They practice both physical and biological conservation measures, including stone and soil bunds, and planting of grasses and fast-growing trees on hedgerows. During mass mobilization, both men and women participated equally in the making of SWC structures. Other family members, including boys and girls have also participated in this activity.

Similarly, both stone and soil bunds have been constructed in the highland areas since recent years. What is very interesting in lowland areas is that the physical structures are maintained every year either communally or individually as required. If such conservation measures were not done in such areas, severe soil erosion and landslides would have jeopardized both the agricultural practices and the lives of the community. Landslide is also a very serious problem in some of the lowland areas, which has been causing loss of lives and assets, because of which farmers have been at risk and appealing to district administration for resettlement in areas suitable for agriculture. In response to this, some households have even been resettled in recent years. Overall, since soil fertility depletion is still the main issue, farmers have realized that SWC intervention measures have proved effective in terms of improving soil and water retention.

Even though attempts have also been made to protect the soil from erosion and reclaim microenvironment through afforestation program, farmers criticized the poor establishment rate of forest seedlings because of very poor management and absence of ownership. Thus, yearly planting of tree seedlings only will not be a sustainable solution without proper management and sense of ownership to the planted seedlings. Otherwise, it is simply wastage of labor and financial resources.

3.4.4 Irrigation development

There is a potential of water resources to develop irrigated agriculture due to the availability of a number of perennial rivers and springs. However, only some of the

farmers practice traditional irrigation agriculture despite the increasing trend from time to time at small scale levels. In spite of the potential in water resources and staggering effort by limited farmers for irrigated agriculture, the practice is not still sufficiently developed. According to experts of the office of agriculture, the following important factors are hindering the growth of irrigated agriculture:

- Attitudinal problems;
- Inadequate awareness;
- Shortage of input supply (improved seeds);
- Limited market linkage;
- Limited implementation of full package of irrigation technology;
- Consideration of irrigation as an additional work by supervisors and DAs;
- Inadequate transportation facilities; and
- Limited implementation of FTC agronomic practices by farmers

It was also recognized that farmers are attracted to irrigated agriculture. For instance, at Boji Gebissa Kebele of Ambo District, a site where case analysis was conducted in this study, about 10-20% of the households in the kebele were estimated to have access to irrigation. Similar trends were also reported to have persisted in other districts as well. Engagement of limited proportion of households in irrigated agriculture was mainly due to shortage of irrigation water that has also restricted the size of irrigated land to be very small. Vegetables are the main irrigated crops produced by farmers which include potato, onion, garlic and green pepper.

Irrigation agriculture is largely of a practice that is being operated by all the household members despite variation in its extent. For instance, in the case analysis site of Ambo district, the participation of men in irrigation agriculture accounts 43% while it is 28% for women and 19% for youth (10 for boys and 9% for girls). The extent of participation could vary from one location to another. For instance, it was estimated that men participation accounts for 26%, women 24% and youths 60% in another case analysis site during the study.

In spite of engagement in irrigation agriculture, the farmers, however, were using traditional practices. Sometimes, there is a conflict among farmers on the use of irrigation water, which is due to shortage of water. In response to this, the community has established an irrigation committee and associated bylaw to solve water related disputes. The water committee had been given the responsibility to implement the bylaw and ensure fair use of irrigation water. In addition, the committee prepares irrigation schedule for the farmers. One of the reasons for water shortage has been that the farmers directly pump irrigation water from rivers. Instead, construction of series of small check dams inside the river channel could have solved the problem of water

shortage. Construction of small check dams can also act as small reservoirs and as water intake point. In the long term, it also helps to recharge the ground water on which many of the farmers may depend on for irrigation. The farmers, however, are lacking improved package of technology for irrigation, such as seed and crop variety, fertilizer types and rate, water requirement of crops, method of irrigation and others. They also urgently need improved verities of horticultural crops. For the farmers who depend on irrigation, disease and insect pests are the main problems that obstructed them from producing high yield and healthy crops for market.

Several perennial rivers can be developed for small-scale irrigation schemes. For instance, there are four perennial rivers in Grar Jarso district, out of which small-scale irrigation scheme is under construction in only one of them. In general, the available water resources have not yet been harnessed to enhance resilience of farmers from climate change effects and food insecurity.

3.4.5 Agricultural machineries and implements

The lack of improved agricultural implements and machineries is, in general, a major problem to adopt modern agricultural practices, such as draining waterlogged Vertisols, row planting, harvesting and threshing. For example, yield of row-planted tef using manual row planting is significantly higher than yield of broadcast-sown tef while manual planting of tef is very labor intensive and tedious. Some farmers are using the broad bed maker (BBM) although many of the farmers still depend on ox-drawn plough to make ridge and furrow for draining Vertisols. BBM beneficiary farmers have managed to practice double cropping on Vertisols. They produce wheat as the first crop by planting on the first week of June and harvesting on the first week of September. Then the second crop is immediately sown, which is chickpea in most cases.

BBM technology has not, however, been largely disseminated though it was generated decades ago because of some technical problems which merit modification. In response to this, BBM was redesigned and simplified to generate BBM (AYBAR), which is believed to solve the problems of the earlier BBM.

Apart from BBM and AYBAR, the farmers have not yet got access to other farm improved farm machineries or implements. They are willing to buy farm machineries and improved implements if they are supplied to them. They believe that such types of machineries will minimize the work burden of their oxen as well as reduce the time taken for planting, threshing, and other farm operations.

3.4.6 Climate change threats

Climate change is expressed in such climatic variables as drought, rainfall variability, frost, and torrential flooding. For instance ten years before, heavy flooding has caused crop damage and yield decline in some of the districts, such as Girar Jarso. Farmers are almost losing short rainy season due to frequent rainfall variability since the last decade. Short rain, which was used to be falling in the months from January to April, has almost stopped because of which the farmers have stopped growing crops. This apparent loss of short rainy season crops has brought about a tremendous negative effect on food security. In addition, the incidence of unexpected frost, for example, in 2016/17 cropping season has severely affected field crops, and led to a sharp decline in yield and total production. Figure 4 illustrates farmers' observations of rainfall pattern in earlier and current days in Grar Jarso. The Figure apparently reveals not only the erratic nature of rainfall distribution but also the decline in rainfall over time. For instance, adequate rain that used to fall in the months from February to May—the short rainy season—has demonstrated inadequacy in recent years failing to support the growth of crops.

On-set and cessation of the main season rain has also changed from its normal course since the last two decades. Main season rainfall has started to commence late and terminate early, largely affecting crop production and productivity. In response to this, however, the farmers have started adjusting planting dates, and changing crop and variety types. Farmers have started replacing long season and high productive varieties with short season and less productive ones. The main problem in this type of situation was reported to be inadequate availability of high yielding and early maturing improved crop varieties. Over time, climate change is bringing changes in farming practices, such as disappearance of long maturing crop varieties and emergence of short maturing ones, the long term consequence of which is declining of genetic diversity.

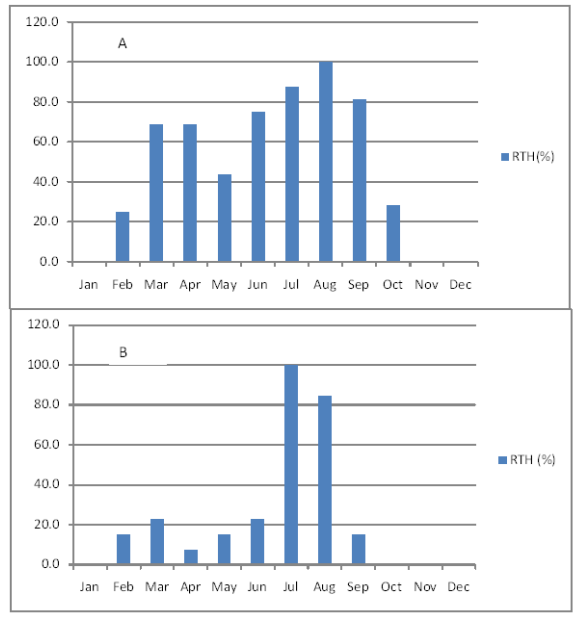

Figure 4. Farmers' observation of rainfall/climate change in earlier normal days (A) and recently (B) at case analysis site of Girar Jarso District

3.5. Cause-effect analysis of farming systems problems

3.5.1 Socio-economic problems

In addition to several problems and proposed solutions presented in the Socio-Economics chapter, this section also provides cause-effect analysis of additional problems that affected women, men and youth (Table 12).

Limited access to and inefficient health services are identified as strategic problems of women and men

- As the types of illnesses change throughout the district for women, which are half of the population, lack of access to adequate health services was reported to affect women severely than men. A functioning health care system is crucial in ending poverty. In addition to inadequate health care access, many women have chronic health issues that have been exacerbated by malnutrition;
- For any complex ailments, rural patients are referred to higher clinics and hospital. However, options for treatment or surgery were recognized to be limited because of severe shortage of doctors and nurses in the districts. According to the World Health Organization (WHO), there were only 1,806 doctors practicing in Ethiopia (2000-2010), which is less than one physician for every 10,000 people. Furthermore, distance has aggravated inaccessibility issue of rural PAs located far away from district towns to health

care centers. All these demonstrate the extent to which women and children are vulnerable to diseases and poor health conditions; and

- In response to the difficulty in accessing healthcare services in the clinics and hospital, many of the women and other household members use traditional healing methods and local medicines.
- **Limited access to agricultural technologies:** In spite of availability of ranges of agricultural technologies, its access to female headed households is still limited on account of inadequate awareness and unaffordability. The problems of access to agricultural technologies have a vicious effect. It has an impact on poverty alleviation, and food and nutritional security; and
- Limited access to technologies for increased productivity aggravates the living condition of especially women that exacerbates food insecurity and poverty.

Limited access to credit service for agricultural inputs: Micro-finance institutions tend to provide group based credit services using the group itself as collateral. Since the entire group, members do not have equal performance and repaying ability, those efficient women and men farmers instead suggested that there should as well be a provision for household based credit service.

Limited access to potable water: Access to potable water is getting a night-mare for rural households. Women and children are especially more affected with lack of potable water. They are the ones who spend a lot of time fetching water which further exacerbates work burden of women. School children also spend lots of their study time fetching water before and after schools. "I fetch water before going to school and after school also" a class 5 school girl said. The consequence of all this keeps women, children and other household members at higher risk of water-borne diseases and spending considerable amount of incomes for medical services.

Strategic intervention options

Considering limited access to hospital and inefficient service problems, the following strategic interventions can be adopted to create healthy and productive society in the farming system:-

- Consolidate achievements in improving access to health care, construction of new health care points in the proximity of PAs;
- Enhance capacities of the health care sectors, including the need to promote greater efficiency and adopt a multidimensional approach to ensure steady improvement in quality of health care for women;
- Increase access/ coverage to health care. Improve service quality through training and an improved supply of necessary inputs. Strengthen management of health services at district and PAs level. Encourage participation of the private sector and NGOs by creating an

enabling environment for participation, coordination and mobilization of funds to improving quality; and

- Revitalization of health center services; speeding up delivery of essential packages of services through the district health system; Improving resource mobilization and the management of resources.

For access to agricultural technologies such as improved poultry, vegetables, fruits, and small ruminants, the following key intervention options are required to address the problem of limited access of farmers to agricultural technologies

There are available technologies that have been developed and generated by the national agricultural research systems for poultry, vegetables, fruits and small ruminants, and others. These technologies need to be packaged, demonstrated and promoted. At the first stage, assessments need to be made from each of the districts on the type and quantities of technologies demanded followed by a program of identifying and tracking the location of the right package of technologies that can suit to agro-ecologies of proposed districts. Along with this, there should also be intensive capacity building initiative for the beneficiaries, DAs and agriculture experts. Other stakeholders across the value chain of the specific technology need also be involved to ensure sustainability.

Limited access to credit service individually for agricultural inputs

To enhance access of rural credit services to the needy farming communities, it is suggested that agricultural finance needs to focus on the following areas:

- In addition to existing group based access to rural credit, micro-finance institutions need also create favorable conditions for access of credit services to individual households who are aspiring to get engaged in productive activities, such as fattening, dairy and others; and
- Segment the smallholder farmers and identify their financial needs**.** Smallholder farmers are heterogeneous and have different needs. It is important to identify various smallholder sub-segments and assess their needs and constraints before designing solutions. Smallholder farmers should be advised to utilize credit for agricultural or productive activities than for other household needs or non-productive activities.

The following intervention options are suggested to address the problems associated with access to potable water:

- Construct and install communal, tap water system in PAs**;** and help families keep their water safe, with awareness creation on mechanisms of drinking water management.

Table 12. Socio-economic problem analysis of women and men

Rank	Problems	Cause	Effect	Intervention	Opportunity	Actors
1	Limited access to health services	No adequate budget allocated for establishing health centers	Morbidity and mortality rate increased	Development of health infrastructures	Favorable health policy	Regional, zonal, and district Health offices
2	Limited access to agricultural technologies (poultry, vegetable, fruit, small ruminants)	Inadequate multiplication and dissemination of technologies, limited	Limited proportion of technology user farmers and meager incomes generated and poor nutritional attainment	Disseminate and promote available technologies and	Availability of research institutes and ready-to-pick technologies	Research institutes, agricultural offices, NGOs and universities
3	Limited access to credit service for agricultural inputs	Unfavorable Credit service procedures and regulations	Inadequate extent of input use practices and limited productivity and production	Establish farmer friendly credit service systems including on household basis, awareness raising and skill building initiatives to make credit use effective and feasible	Availability of credit institutions at district levels and commitment of the government to provide financial supports to agricultural investment	Micro-finance Institutions, Office of Agriculture, NGOs
4	Limited access to potable water	Rivers polluted and located far away from villages	Vulnerable to water borne diseases, economic crisis for medication	Developing water points in close proximity, conserving natural resources, and protecting pollution	There is ground water potential and rivers around	Regional, zonal, and district Water Resource Office, Office of Agriculture, NGOs
5	There are no women based cooperatives	Limited women friendly technologies that can initiate the cooperative system for women	Limited participation of women in economic activities, Poverty, unemployment,	Focus on generating, promoting and disseminating women friendly technologies, establish women based cooperatives, raise women's awareness and skills	Willingness of women to involve in different cooperatives for wealth creation,	Cooperative Offices, Research institutes, agricultural office, NGOs and universities

6	Limited access to irrigation	Inadequate investment plans and resources allocated to establish irrigation facilities	Vulnerability to climate change (drought), limited production and productivity, food, nutrition and income insecurity	* Provide due focus to allocating adequate resources for developing irrigational development schemes * Develop and promote irrigation technologies	Ground water potential, irrigable rivers and streams, farmers willingness to participate for the scheme development	Federal, Regional, zonal, and district Office of Agriculture, MOFEC, NGOs, Research Institutions, Universities
7	Limited access to electric power to minimize domestic workloads	Limited investments for rural electrification program	Increased Workload on women, limited economic opportunities for farmers	Increase resources for rural electrification	Favorable government policy for rural electrification, many power stations under development	Federal, Regional, zonal, and district offices of Energy, MOFEC
8	Inadequate progress of family planning initiatives in rural areas	Limited access to contraceptives, social taboos on contraceptive	Increased birth rate increases, population pressure, increased unemployment	Awareness raising and Creating access to contraceptive and training on the use of contraceptives to the society	Women are interested and willingness to apply contraceptives, favorable government policy to address health problems, availability of health posts at kebele levels	Federal Ministry of Health and Regional Health Bureau, NGOs
9	Inadequate technologies for mechanization	Limited availability of user friendly and affordable farm implements for smallholders	Inefficiency in farming limited productivity and increased workloads and inadequate use of improved technologies, such as row planting	Promote and disseminate available farm implements for smallholders and link the supply with credit institutions	Farmers willingness to adopt the technologies, availability of improved farm mechanization technologies and manufacturers	Agricultural research institutes, regional, zonal, district office of Agriculture, NGOs, Microfinance Institutions and Farm Tool Manufacturing Companies

10	Inadequate access to animal health services and low efficacy of vet drugs	Inadequate availability of vet drugs with high degree of efficacy, importation of poor quality vet drugs	Animal mortality rate increases, livestock productivity declines	Strengthen quality control for imported vet drugs and facilitate importation of standard vet drugs	Availability of several vet drug importers in the country and an Authority established for quality controls of vet drugs	Ministry of Livestock and Fishery, National Bank of Ethiopia, Veterinary Drugs and Feeds Administration and Control Authority
11	Land scarcity and increased land fragmentation	Population pressure	Increased unemployment, food and income insecurity, poverty, degradation of natural resources	Promote intensive agriculture and productive technologies on limited plot of land, focus on small ruminant fattening, poultry, bee keeping	Government commitment to transform agriculture sector and availability of several agriculture based programs, projects and initiatives	Agricultural Research Institutions, Universities, ATA, AGP, Bureau of Agriculture, NGOs

Strategic problems of youth

Limited employment opportunities

In rural areas, youth unemployment is growing over time, which also results to increased rural poverty. After a long time of unemployment, youths get desperate and tempt to find the wrong way to earn money, to get rid of unemployment stress. They also become addicted to alcohol or drugs, and finally become hopeless to life. The unemployment problem in the districts has revealed alarming dimensions since the last decades. Among the many factors that have contributed to unemployment are the following:

- **High population growth:** The increase in population has further aggravated the unemployment ;
- **Insufficient rate of economic progress:** the rate of economic growth is inadequate to absorb the entire labor force;
- **Absence of alternative employment opportunities other than agriculture:** As other employment opportunities are not adequately established, agriculture is the principal area of employment in the district. However, agriculture could not absorb the unemployed youth due to land shortage;
- **Seasonal employment:** agriculture in the districts offers seasonal employment; thus agricultural labor remains idle during the off-season;
- **Joint family system:** existence of joint family system in the districts promotes disguised unemployment. Usually the members of a family work on their family farms or do family business. There are more workers on a family farm than what would be needed resulting in labor inefficiency;
- **Increasing turnout of students from high school:** educated, but unemployed youth have increased due to rapid turnout of graduates from high schools and universities; and
- **Slow development of industries:** industrialization is not rapid in district towns and the available labor finds a few job opportunities. The agricultural surplus labor force is not absorbed by the industrial sector. This leads to disguised unemployment in agriculture.

Strategic interventions for youth

Following are the suggestions to solve unemployment problem for youth with wide spectrum interventions in the short and long-term basis:

- Enhance the knowledge and skills of youths on entrepreneurships and businesses, accounting and others depending on their needs and the context of their locality. They should be encouraged to create a job of their own using favorable opportunities and resources available, and accessible to them. This can be strengthened through experience sharing visits to model youth sectors with successful business ventures;
- Strengthen availability of favorable credit services for youths to be engaged in profitable business enterprises. For instance, youth could be engaged in cattle and small ruminant fattening, dairy production, feed processing, apiculture, fruits and vegetables and others.

Depending on their interests, other opportunities can include carpentry, barberry, wood-works, and other artisanship. How to engage and get successful in wholesale and retail trade sectors could also be another opportunity to which credit services are required;

- More assistance to self-employed youth: self-creativity in agriculture, trade, cottage and small-scale industries etc., should be encouraged via different provisions such as subsidy, and access to land and credit. Moreover, such youth should be supported with required raw materials and skill training;
- Employment creation programs: accelerate in planning and implementing employment opportunities vis-a-vice different theme that can even sustain long-term productivity to the environment and community more importance should be given to employment. The programs like irrigation, roads, flood control, conservation, agriculture, town sanitation, rural compost fertilizers business, can provide better employment to youth; and
- Industries in co-operative sector: industries in co-operative sector should be encouraged. This is a novel approach to fight against unemployment in rural areas near to main roads and district towns.

3.5.2 Cause-effect analysis of crop production problems

In addition to several problems and suggested solutions that have been presented in the aforementioned chapter of crop production, this section provides in-depth analysis of the causes, effects, intervention options and opportunities available to improve crop production and productivity. Table 13 reveals the problems and corresponding causes, effects and suggested recommendations along with further descriptions in subsequent sections.

The major problems identified in crop production included crop diseases and insect pests, high prices of inputs, knowledge gap in input usage, erratic rainfall distribution, land degradation and others (Table 13).

Table 13. Cause-effect analysis of crop production problems

Problem	Cause	Effect	Possible solution	Opportunities	Actors
Disease problems: ▪ Wheat rust and foot rot; ▪ Onion rust ▪ Garlic root rot ▪ Maize virus MLND ▪ Existing and emerging faba bean diseases	▪ Breaking down of resistant genes of previously resistant varieties (e.g., wheat rust) ▪ Climate change	▪ Attack of the crops by the disease and insect pests ▪ Low productivity and poor quality of the produce	▪ Promotion and dissemination of the existing improved varieties with full package ▪ Development of new diseases resistant varieties; ▪ Develop disease control options ▪ Use integrated disease management practices	▪ Availability of some resistant or tolerant cultivars ▪ Availability of resistance genes elsewhere to be used in resistant varieties development	Agricultural Research Institutions; HLIs, Regional Bureau of Agriculture, CGIAR centers
Insect pest problems: ▪ Tef shoot fly; ▪ Field pea and grass pea bollworm and aphids; ▪ Emergence of fall armyworm ▪ Termite problem	▪ Shortage of resistant varieties; ▪ Climate change	▪ Low productivity and poor quality of the produce	▪ Use of already existing varieties with full package ▪ Development of integrated pest management (IPM) options ▪ Use of IPM for the control of the pests; ▪ Research on the different control options	Availability of relatively resistant or tolerant varieties from the research system	Agricultural Research Institutions; HLIs, Regional Bureau of Agriculture, CGIAR centers
▪ High input prices: ▪ Fertilizer ▪ Herbicides ▪ Insecticides ▪ Improved seed	▪ Less regulated input market where traders impose unfair prices ▪ Shortage of adequate input supply in the market	▪ Low or no use of the inputs resulting in low yield	▪ Avail affordable small packs; ▪ Increase supply of inputs through Coops. ▪ Providing initial seed for resource poor farmers in kind; ▪ Providing credit options	Availability of coops	BoANR, Coops, National Bank of Ethiopia (to provide hard currency for imports)
Knowledge gap on input usage	Inadequate initiatives on awareness raising	▪ Inappropriate use of safety measures on chemicals and detrimental effects on human health; ▪ Under dose or under	▪ Giving training on input use (especially chemicals) and safety measures	Availability of trained human resource in research system and zonal and District Offices of Agriculture	Agricultural Research Institutions; HLIs, Regional Bureau of Agriculture, NGOs

		dose use of inputs (fertilizer andpest control chemicals)and consequent deterioration of productivity			
Shortage of initial capital: ▪ To purchase farm inputs	Poverty and unfavorable credit services to smallholder farmers	No or low use of input resulting in low productivity and production, and then food insecurity and vicious circle of poverty	• Availing favorable credit opportunities to smallholders;	Conducive policy environment; Availability of micro-finances	BoANR Credit association, Banks
▪ Shortage and erratic distribution of rainfall: ▪ Late onset and early cessation resulting in terminal stress ▪ Occurrence of drought	▪ Climate change	▪ Affecting crop production activities (land preparation, planting and harvesting) ▪ Inflicting crop damage (e.g. drought, frost, flood, hail damage)	▪ Develop climate change resilient technologies (varieties); ▪ Use of water-harvest technologies; ▪ Use of irrigation schemes	▪ Availability of water sources for irrigation; ▪ Availability of irrigable land; ▪ Availability of crop varieties that could fit into different climatic conditions	The research system, BoANR, Meteorology Agency, CGIAR Centers
Land degradation and poor soil fertility;	▪ Deforestation and removal of natural vegetation ▪ Lack of enforcement of land-use policy	▪ Erosion of the soil and gulley formation ▪ Out of their natural bank flow of rivers	▪ A forestation; ▪ Enforcing land use policy; ▪ Use of soil conservation structures; ▪ Sustainable farming ▪ River training	Availability of land use policy	BoANR, Research systems, NGOs
High turnover of agricultural experts (DA's, SMS)	▪ Appointment in higher position; ▪ Leave for further education; ▪ Job dissatisfaction	Inadequate extension and advisory service for the farmers, and consequently less use of agricultural technologies	▪ Create conducive environment for the experts; ▪ Avail incentives and access to higher learning	Availability of trained human resource for employment	BoANR, HLI, Regional States
Problem related to credit services	▪ Inconvenience with group collateral (high number of	Inadequate finance to invest in inputs, small	Providing credit opportunity along with reduced interest rate;	Conducive policy ;	Micro Finance Institutions , Zonal

	defaulters) ▪ High interest rate (i.e., 18%)	businesses and agricultural commercialization		Availability of micro-finances	and District Offices of Agriculture, NGOs
Agricultural land shortage for youth (male and female)	Ever increasing population and	▪ Further fragmentation of land to grow crop; ▪ Little produce to sustain family	▪ Job opportunity creation other than farming ▪ Increasing productivity per unit of land through promotion and dissemination of technologies	Availability of Agricultural Research Institutions, HLIs and technologies for intensification	Agricultural Research Institutions, HLIs, Zonal and District Offices of Agri., CGIAR centers, NGOs
Knowledge gap in running small businesses (off-farm IGAs)	Lack of training on small businesses, business plan, saving, etc and lack of initial capital	Vulnerability to food insecurity and poor resilience to climate change hazards	Enhance farmers' income sources through options of activities and avail favorable credit services for initial capital	Options of IGAs available, farmers' demand raised for IGAs, Micro Finance Institutions available to meet financial needs for feasible businesses	Zonal and District Offices of Agriculture, Micro Finance Institutions, NGOs

Intervention options for crop production constraints

1. Demonstration and popularization of existing packages of crop production technologies: Complete package of the existing production technologies (improved seed along with appropriate agronomic and crop protection practices) should be demonstrated and popularized to the farmers. For example, there are released varieties for different agro-ecologies, recommended seed and fertilizer rates, disease and insect pest, weed and post-harvest pest control options. These packages should reach each farmer to boost productivity and production. It is a well-documented fact that there is a huge gap between the average national productivity, the attainable productivity on farm using improved packages and the potential of the crop under ideal condition. For example, the national average yield of faba bean is about 1.9 t/ha (CSA, 2015) while the average on-farm attainable productivity of improved faba bean varieties along with improved crop management practices is around 3.5 t/ha. Therefore, this huge yield gap is believed to be bridged up by proper demonstration and popularization of the technologies to the farmers through the extension system.

2. Introduction and / or development of improved crop varieties: The research system should keep on developing and disseminating stable, high yielding, disease and insect pests and stress resistant/tolerant crop varieties along with their appropriate crop management practices. In addition, introduction of adaptive released varieties elsewhere and conducting accelerated multi-location test and accelerated release of good performing varieties could be one intervention option.

3. Enhancing initial seed multiplication: Breeder seed should be multiplied in sufficient quantity to supply to seed producers (federal and regional public seed enterprises, private seed producers, and farmers' groups). This could be implemented through decentralized seed production scheme in which research centers multiply initial seeds of the crops for their respective areas. The seed multiplication effort could be enhanced using off-season in addition to main season rainfall and using modern irrigation facilities. In addition, biotechnology tools such as tissue culture could be used for multiplication of disease free planting materials for crops like potato.

Apart from the formal seed system, the informal seed system plays significant role in seed multiplication and supply system where farmers themselves or farmers' cooperatives produce seeds and sell to or exchange with other farmers. The strengthening of this system with some technical assistance from the research system and relevant governmental and non-governmental development organizations is very essential. In crops like faba bean that require relatively higher seed rates per unit area, the informal seed system should support the formal seed system to fulfill the national demand. This could be accomplished through the annual or biannual provision of

certified or basic seeds to progressive farmers and farmers' cooperatives with the necessary technical back-ups from breeders, seed technologists or extension workers. Proper training on seed production and the necessary facilities like mobile seed cleaners, seed testing laboratories and facilities should be made available to the farmers and the cooperatives until they are both technically and materially capable to carry out all tasks by themselves.

4. Disease and pest control options: Enhance the use of already developed disease, insect and weed control options. In this regard application of location specific integrated crop management practices mainly good agronomic practices, fertilizer application and crop protection are appropriate to reduce the impacts of pests at farm level. In addition, demonstration and validation of already identified integrated pest management (IPM) options is equally important to boost the productivity of crops and create better awareness for smallholder famers on pest management. In a short run it is imperative that farmers should be trained on appropriate and safe use of pest control chemicals. In the long run it is also important to keep on identifying adaptive and appropriate integrated pest management practices. In this case, developing pest resistant crop varieties, identification of effective, safe and economical pesticides is deemed necessary and appropriate for smallholder farmers to improve their production and productivity at farm level.

5. Determination and use of small pack inputs: The already existing agricultural production inputs should be packed in small packs that can easily be used by smallholder farmers. For example, the recommendation of fertilizer and seed rate per hectare basis could be packed in smaller packs of half or a quarter of a hectare so that it could easily be picked by the farmers. The small packs are economically affordable by farmers, easy to apply and also could reach as many farmers as possible. This enhances the utilization of the already existing appropriate and economical recommendation on seed and fertilizer rates for different agro-ecologies. The newly developed agronomic recommendations for different agro-ecologies should be packed in smaller packages as well.

6. Enhance capacity of input providers: Provide technical support to seed producers for the production of quality and sufficient quantity of crop varieties. For example, the existing seed quality laboratories could be strengthened in physical facilities and human capacity.

Other options of interventions

Include enhancing demonstration and popularization of improved technologies through tailored training for farmers, DA's and SMS, and developing leaflets, fliers,

production manuals in different local languages of improved technologies, and strengthening the linkage with concerned stakeholders should also be given due attention.

Gender mainstreaming

At all levels from problem identification to technology development should be strengthened. Due emphasis should also be given in developing technologies that reduce the workloads of women farmers.

Modern farm implements

Enhance the use of appropriate modern farm implements that could be used by smallholder farmers to increase labor efficiency, increase production and productivity.

3.5.3 Cause-effect analysis of livestock production problems

Apart from the constraints that have been revealed in the preceding livestock production chapter, this section as well provides details of causes and effects of the constraints identified in livestock production (Table 14). The major constraints include feed shortage, shortage of improved livestock breeds, prevalence of various livestock diseases, inefficient milk marketing system, shortage of pure water supply, and low awareness of farmers on available livestock technologies. The causes, effects, possible intervention options, available opportunities and major actors are also provided against each of the constraints in the table followed by further brief descriptions of the problems and suggested interventions.

Table 14. The causes, effects and potential intervention options for the major livestock production constraints

S/N	Constraint	Causes	Effects	Possible intervention options	Available opportunities	Actors
1	Feed shortage	• Shrinking area of grazing land in favor of expansion of cropping, urbanization and investment in other sectors (floriculture, different industries, etc) • Lack of enforcement mechanism for proper delineation of grazing lands • Human and livestock population pressure • Dependence of farming on animal power • Low adoption of available feed technologies • Shortage of improved forage seeds – lack of effective forage seed production and supply systems • Inefficient management and utilization of available feed resources • Extended dry season • Limited access to AIBPs and lack of regulation in feed marketing	• Low livestock productivity • Over grazing leading to land degradation • High feed cost • Death of animals in extreme situations • Reduction in draft oxen supply/draft power output • Shortage and/or high cost of livestock products • Reduced contribution of livestock to national economy (e.g. in terms of generating foreign currency)	• Strengthen demonstration of available feed technologies • Generate tangible evidence to verify that forages are competitive and better enterprise choices to enhance adoption by users • Establish/strengthen improved forage seed production and supply system • Strengthen the extension system to popularize the improved feed technologies and/or ensure efficient utilization of available feed resources • Enforce land use system to ensure proper delineation of grazing land that matches with existing livestock • Introduce mechanization in applicable areas to reduce dependence of crop agriculture on animal power (enable to keep only few productive animals for the production of livestock products) • Improve access to AIBPs at fair/affordable prices (distribution and price regulation)	• Availability of improved forage varieties recommended for different agro-ecologies • Ambitious plan for forage development in livestock development master plan • Increasing demand for livestock products • Growing demand for feed technologies and presence of research centers and universities engaged in feed research • Presence of regional, zonal and district level experts, and kebele level DAs to facilitate feed technology dissemination • Presence of different partner organizations working on feed technology promotion (NGOs like VOCA, ATA, FAO, etc)	• Farmers • MoLF (at different levels) • MoANR (at different levels) • Research (EIAR, RARIs, HLIs, etc) • NGOs • Seed enterprises (ESE, RSEs, private seed companies)
2	Inadequate supply of improved livestock breeds (crossbred heifers)	• Shortage of heifer multiplication centers/ranches • Inefficient AI delivery system (limited liquid N plants, AI technicians, required facilities and infrastructure,	• Low supply of livestock products • High cost of livestock products • High cost of improved dairy heifers	• Strengthen community based breeding programs to improve genetic progress and milk production (should be accompanied by accurate recording)	• Presence of conducive environment for dairy production • Increasing demand for dairy products	• Farmers • MoLF (at different levels) • Research (EIAR, RARIs,

		etc) • Long-term nature of the breed improvement program (mainly cattle) • Low success rate of estrous synchronization (animal condition/proper selection, management, follow-up, etc) • Lack of specialized livestock/dairy production and targeted/focused extension service delivery • Limited incentive mechanisms and policy provisions for livestock/dairy related investments (land, credit, taxation, etc)	• Very low per capita consumption of livestock products (milk~20 liters/annum; meat~10 kg/annum; egg~0.5 kg/annum) • High expenditure for importing livestock products (mainly powder milk) • Limited private sector involvement in livestock/dairy related investment	• Establish improved heifer multiplication centers in potential dairy shed areas and/or strengthen existing ones • Improve efficiency of the AI system (expand semen processing and liquid N plants, train and deploy more AI technicians, avail required facilities such motor bikes in sufficient quantities, etc) • Adopt best practices and workable modalities to improve efficiency and success rate of estrous synchronization (a function of animal/management, technician, supplies, facilities, etc) • Develop a targeted extension approach for areas with comparative suitability to dairy production (e.g. Selale area) • Establish attractive policy provisions to stimulate livestock/dairy related investments	• Presence of different research centers and HLIs engaged in livestock/dairy research • Presence of regional, zonal and district level experts, and kebele level DAs to facilitate livestock/dairy technology dissemination • Presence of institution devoted to semen processing and distribution (NAIC) • Presence of Livestock Development Master Plan • Establishment of liquid N plant in different regional towns (e.g. Fiche, Shashemene, Nekemte, etc) • Presence of ADPLAC platform	HLIs, etc) • NGOs • NAIC
3	Prevalence of livestock diseases	• Poor access to veterinary clinics (vet. clinics are mainly located around or within urban centers) • Shortage of drugs and other required facilities in the vet. clinics • Low efficacy of veterinary drugs and vaccines • Various pre-disposing factors (drought, unclean/stagnant water and grazing on waterlogged areas harboring parasites and different	• Livestock morbidity and mortality • Loss in animal condition and reduced productivity • Possible development of drug resistance by microbes Reduction in draft power output	• Strengthen disease control and prevention measures (establish early warning and awareness raising systems) • Regular vaccinations against important diseases • Drug quality and resistance analysis • Expand veterinary clinics and strengthen the existing ones	• Availability of trained veterinarians • Presence of different research centers and HLIs engaged in animal health research • Presence of national animal health laboratory at Sebeta • Presence of institution devoted to vaccine	• Farmers • MoLF (at different levels) • Research (EIAR, RARIs, HLIs, etc) • NVI • Sebeta animal health laboratory

		disease causing agents) • Shortage of facilities for mobile veterinary services (like transportation, equipment, crushes, etc)			development and distribution (NVI)	
4	Inefficient milk marketing system	• Lack of binding regulation in milk marketing • Lack of pricing system based on milk quality standard Lack of easy to use and cheap milk quality analysis tools • Weakening of available dairy cooperative unions (e.g. Selale Dairy Union) • Involvement of many actors in the milk value chain • Concentration of milk processing plants away from potential dairy shed areas (mainly in Addis) • Low level of awareness of farmers on milk quality management and associated risk	• High gap in milk price between the farm gate and the terminal market (at least a double of the farm gate price at terminal market) • Adulterations at different stages leading to low milk quality • Farm gate prices mainly set by the will of collectors (limited bargaining power by producers)	• Establish regulation for standard milk marketing system (pricing based on quality) • Encourage establishment of more milk processing plants in the potential milk shed areas in order to minimize involvement of the middle actors • Strengthen dairy cooperative unions • Regular awareness trainings to producers on quality milk production • Ensure that importation of powder milk will not negatively affect local producers (invest the money used for import to improve the domestic system)	• High demand for milk and other dairy products • Presence of institutions such as EMMTI (Ethiopian Milk and Meat Technology Institute) • Emergence of milk processing plants	• Farmers • MoLF (at different levels) • Research (EIAR, RARIs, HLIs, etc) • Commercial dairy producers • EMMTI • Milk processing companies • Dairy cooperatives
5	Shortage of pure water supply	• Drying-up of available surface water resources (rivers, streams) during dry season • Deforestation and expansion of farming to the edge of water points	• Reduced livestock productivity due to water deprivation • Animals are forced to drink on stagnant and unclean water resources which pre-dispose them to water born diseases and parasites (e.g. Leech) • Wastage of farmers time and energy in moving animals long distances in search of watering points	• Strengthen watershed based NRC • Minimize disturbances (deforestation, ploughing) around available water points – re-enforcement with additional afforestation program • Develop alternative water sources (boreholes, diversion perennial rivers where applicable, etc) • Explore why rain water harvesting failed to sustain and devise	• On-going NRC initiatives • Presence of perennial rivers in different areas • Presence of water development authority at various levels (regional, zonal and district)	• Farmers • MoLF (at different levels) • Water development offices • Research • NGOs

				strategies for possible revitalization		
6	Low awareness of farmers on improved livestock technologies	• In adequate training and other awareness raising programs (experience sharing visits, farmer field days, etc)	• Limited knowledge on available technologies and their applications	• Conduct regular trainings and arrange other knowledge sharing programs • Prepare easily understood communication materials (leaf lets, manuals, fliers, etc) to farmers, DAs and other users	• Presence of research centers and HLIs to serve as source of knowledge and information • Presence of regional, zonal and district level experts, and kebele level DAs to facilitate the knowledge sharing programs • Presence of model farmers who can share their best practices in different areas • Presence of ADPLAC platform	• Farmers • MoLF (at different levels) • Research • NGOs

Problems and suggested intervention options in livestock production

Strategic problem 1:- Feed shortage

Shortage of quality feed supply has been reported to be the most widespread constraint hampering livestock production and productivity, which is also the case in most livestock production systems in Ethiopia. One important cause for feed shortage is the ever shrinkage in area of grazing lands and the wider mismatch with the available livestock. Grazing lands account only for about 10 to 15% of the total land and overstocked with more than five-fold of the recommended carrying capacity (~3 TLU/ha/year). Moreover, areas considered as grazing lands are those fragmented lands not suitable for arable farming due to various edaphic and topographical limitations. Such grazing lands are characterized by low productivity and poor feed quality due to continuous overgrazing leading to dominance of unpalatable pasture species.

Although different crop residues are seasonally produced from the cropping system, they are inherently of low quality and cannot meet nutritional needs of animals—especially in market-oriented production systems. Moreover, there are limitations with respect to proper collection, conservation, improvement (physical and chemical treatments) and utilization of crop residues. Use of AIBPs as feed supplements is also limited due to lack of access and high cost especially by non-market oriented livestock producers under the rural setting in the study areas.

In order to widen the feed supply options, the national agricultural research system has identified and released more than 40 well adapted, high yielding and nutritious forage species/varieties for different agro-ecological zones and production systems of the country. The improved forage species on average produce about ten-fold more forage yield per unit area relative to the continuously grazed natural pasture. They have also other multiple roles in the farming system including improving soil fertility, food-feed supply, control erosion, weeds, pests and diseases when integrated in cropping systems, provide bee forage, fuel wood and help as wind breaks when planted as live fences around the homesteads. Generally, use of cultivated forage crops is an important step in supporting and improving market-oriented livestock production while maintaining environmental sustainability both at smallholder farmer and at commercial levels.

Despite their immense potential to curb feed shortage and the aforementioned multiple beneficial roles, cultivated fodder crops have been underutilized, in particular. One major reason for this shortfall is that the agronomic production management, biological, economic and environmental benefits of best-bet forage crops has not been adequately demonstrated to support informed decisions by farmers. In addition, the very subsistent nature of livestock producers and lack of market orientation have

imposed critical limitation on the use of improved feed technologies. In view of these, the following intervention options have been suggested for possible action by AGP-II and beyond:-

Intervention option 1.1. Strengthen on-farm demonstration and promotion of available feed technologies

This is meant to undertake on-farm participatory evaluation and demonstration of proven forage technologies in order to identify suitable species and mechanisms for wider dissemination and utilization. List of potential forage species to be targeted (but not the only) for intervention are shown in Table 15. On account of comparative availability of seeds/vegetative planting materials, ease of establishment, overall management and applications, oats/vetch mix, Elephant grass, desho grass, tree lucerne and sesbania may be primarily focused for immediate intervention in the highland and mid altitude agro-ecologies of the target districts. Moreover, linking the intervention with market-oriented livestock production such as improved dairying should be considered as an approach to ensure better adoption of improved fodder crops.

Table 15. Some potential candidate forage species to be targeted for intervention

Intended use or Application	Candidate forage species	Potential yield (t DM/ha)	Altitude(m)
Field production and cut-and-carry green feeding and/or conservation as hay	Oats/vetch mix	10 - 15	1500 – 3000
	Desho grass	20 - 30	1000 – 2800
	Rhodes grass	10 - 20	Below 2400
Intensive fodder development and cut-and-carry green feeding (Backyard and/or along irrigation canals if any)	Elephant grass	10 - 30	Below 2400
	Desho grass	20 - 30	1000 – 2800
Backyard and/or conservation- based fodder development as supplementary livestock feed	Tree lucerne	10 - 12	Above 2400
	sesbania	8 - 10	Below 2400

Intervention option 1.2. Conduct plot level designed studies and generate tangible evidence in order to verify that forages are competitive and better enterprise choices to enhance adoption by users

Land is usually the scarce resource of smallholder farmers and the decision in allocating land for different purposes will depend on the relative economic benefit of the enterprise. Moreover, the farm gate price of one bale of hay (~16 kg) ranges from 50-100 Birr based on the season while its retail price is about 150 Birr per bale in the city of Addis Ababa. From a well-managed oats field, at least 8 t DM (32 tone fresh feed and an estimated 500 bales of hay) can be produced per hectare which can generate tremendous amount of income to the farmer. However, there is no research

evidence to verify such information. Therefore, designed plot level studies should be conducted to evaluate the economic benefit of growing best-bet forage species identified for the different target areas. The information will help the farmers to make informed decisions towards the most feasible enterprise choice in resource allocation (land, labor, and capital).

Intervention option 1.3. Promote and strengthen informal forage seed production and supply scheme

Sustainable production and utilization of the best-bet forage species will depend on reliable supply of good quality seed/vegetative planting material at affordable prices. However, formal forage seed scheme is lacking and/or not well developed in Ethiopia. Therefore, it is essential to strengthen and promote informal forage seed production by engaging selected model farmers and private seed companies, such as Eden-field Agri-business. In this regard, the research system will play important roles in availing starter seeds, provisions of training on seed production and management, and in creating market linkages in collaboration with other stakeholders.

Intervention option 1.4. Promote proper management, improvement and conservation strategies to ensure efficient utilization of locally available feed resources (like crop residues)

Farmers face 4 to 6 months dry season where feed is scarce and expensive. Farmers also face critical feed shortages during the main rainy season as crops cover most of the land with little account for grazing. On the other hand, substantial quantities of crop residues are produced during the main grain-harvesting season (October to December). Hence, proper collection and preservation in suitable form is one option to ensure year-round feed availability. Crop residue conservation and utilization should also be accompanied by different physical and chemical treatment methods to improve their nutritional quality.

In addition, Urea-Molasses Multi-nutrient Block (UMMNB) technology should be introduced and promoted as supplement to crop residue based feeding. The expansion of sugar industries and increased supply of molasses is a good opportunity in this regard, provided strategy for its efficient distribution and storage is devised. Dairy farmers at Girar-Jarso district in Selale have reported to purchase one liter of molasses for 12 Birr while the factory-gate price is very low (<1 Birr/Liter). Therefore, how such wide price gaps could be narrowed down will also be subjected to possible interventions.

Intervention option 1.5. Enforcement of available land use policies to ensure proper delineation of grazing lands that match with existing livestock

The existing trend clearly shows that grazing lands as sources of livestock feed have a very limited prospect unless policy enforcement measures are taken to delineate a fair share of grazing land to ensure sustainability of both crop and livestock production.

Intervention option 1.6. Introduction of mechanization in applicable areas in order to minimize dependence of farming on animal power thereby encouraging farmers to keep few productive animals (intensification) with main aim of producing livestock products

The main purpose of keeping cattle by smallholder mixed farmers is to secure adequate supply of draught oxen for farming. In order to secure a pair of oxen, a farmer is always opting to keep 3–4 female cattle, which necessitate keeping 5-6 unproductive cattle per household. If the main purpose of keeping cattle is to produce livestock product (like milk), one or two productive/crossbred cows could be sufficient per household in which intensification may be possible. Therefore, possible introduction of mechanization in applicable areas can potentially help to reduce dependency of crop agriculture on animal power and thereby paves a way to improve productivity of the livestock sector through intensification. Moreover, areas, which have comparative suitability to livestock production like North Shewa (Selale), should be focused for a targeted development intervention and extension services gearing towards livestock/dairy production.

Strategic problem 2: Inadequate supply of improved dairy heifers

Availability and consumption of milk and other livestock products in the study areas is very low except at Girar-Jarso district. In addition, prices of livestock products including milk and milk products are increasing from time to time and become unaffordable by majority of the consumers. Such shortage in animal products will significantly affect food and nutritional security, and hamper the process of building healthy and productive society. One major factor limiting availability of dairy products is the inadequate supply of improved dairy heifers/cows, which only account for less than 1% of the total cattle population in the country. This is mainly due to less efficiency of artificial insemination (AI) delivery system, high price of crossbred cattle and lack of appropriate breeding program at farmer level to produce sufficient and adaptive crossbred dairy cattle in the country. Most farmers cannot afford to buy improved dairy cattle. For instance, the prices of non-pregnant and pregnant crossbred heifers were respectively about 20000 and 35000 Birr according to the information from surveyed districts. In order to improve this situation, the following intervention options have been suggested for possible actions.

Intervention option 2.1. Strengthen community based breeding programs to improve cattle genetic make-up and milk production

Farmers who have adopted the introduced improved dairy technology have witnessed that keeping one crossbred cow is much worthier than keeping 3-5 indigenous milking cows in terms of milk production and income generation. In addition, the study by Agajie. (2016) in Oromia Region has shown that adopters of crossbred cows technology could generate 44% more income than non-adopters. Thus, it is essential to strengthen further introduction of improved dairy heifers in areas where dairy was less promoted and also community based breeding programs to improve genetic make-up of dairy cattle in suitable areas—in terms of environment, market access, and inputs. However, both livestock experts and farmers in the study areas have emphasized that breed improvement efforts have been highly influenced by less access by farmers to AI centers, inconsistent supply of AI inputs and shortage of AI technicians. Hence, the breed improvement programs should be accompanied with improving efficiency of the AI system including robust semen processing and expansion of liquid N plants, training, and deployment of more AI technicians, availing required facilities such as motor bikes and other equipment's in sufficient quantities. Moreover, it is important to assess and devise alternative AI delivery to improve efficiency and success rate of AI and estrous synchronization, which is a function of animal condition/management, technician, supplies, and facilities. Furthermore, there are no appropriate recording system in place at farmers' level to determine the level of exotic inheritance as well as to evaluate performance and survival of crosses under farmers' management condition for further improvement. Hence, the genetic improvement efforts should be augmented by reinforcing the crossbreeding activities with appropriate recording schemes. This intervention requires close collaboration of research and development actors (MoLF, NAIC and NGOs).

Intervention option 2.2. Establish improved heifer multiplication centers in potential dairy shed areas and/or strengthen existing ones

Availing initial stock of improved dairy heifers at affordable prices will help to enhance the breed improvement program and improve milk production. Experiences in other countries like India have shown that the "**one crossbred heifer per household**" policy which was consistently implemented for a long period (more than 20 years) was the major driving factor for the success of white revolution. Therefore, establishing and strengthening heifer multiplication centers in suitable areas should be given a strong emphasis to improve the dairy sector in Ethiopia.

Intervention option 2.3. Develop a targeted extension approach for areas with comparative suitability to dairy production

There is a need to develop and implement targeted extension services according to comparative suitability of different areas for different enterprises rather than following a blanket extension approach. For instance, we do not have a different extension approach for Selale area that is highly suitable for dairy production Vs other areas, which have better comparative advantage for grain production. Therefore, studies should be conducted on the existing extension service delivery system to generate recommendations on possible re-orientation of the extension system in a way that allows proper exploitation of area specific potentials thereby improve overall productivity.

Intervention option 2.4. Establish attractive policy provisions to stimulate private sector investment on livestock/dairy

Investments in livestock—mainly dairy production—require a long time to mature and generate return. Therefore, different policy provisions and stimulatory measures should be devised to attract more private sectors.

Strategic problem 3:- Prevalence of livestock diseases

Prevalence of different livestock diseases—Mastitis, Milk fever, Black leg, Anthrax, Pasteurellosis, FMD, Lumpy skin disease—and parasites like Leech in cattle, Ovine rinderpest /Peste des Petits ruminants (PPR) in small ruminants and Newcastle (NCD) and Coccidiosis in chicken were reported to be the major problems of livestock production in the study areas. Low efficacy of veterinary drugs and vaccines, poor access of veterinary clinics to farmers located far away from urban centers (5 or more kilometers), shortage of drugs and required facilities/equipment's in the veterinary clinics and low awareness level of farmers on modern animal management are the important factors affecting disease prevention, control and treatment endeavors. Veterinary professionals believed that vaccines used against Pasteurellosis, Peste des Petits ruminants (PPR) and lumpy skin disease (LSD) are not effectively preventing the outbreaks in recent years. Moreover, there has been a big concern for possible development of drug resistance by microbes. This might be due to lack of regulation and strict control on the transaction of veterinary drugs. In many areas, there are cases where drugs are informally sold and animals are treated without diagnosis and professional prescriptions. Therefore, the following intervention options have been suggested for possible action by AGP-II and beyond:

Intervention option 3.1. Strengthen disease control and prevention measures—establish early warning and awareness raising systems

Proper understanding of disease seasonal calendar followed by effective early warning and awareness raising systems is the basis for prevention and control of livestock diseases. This should also be accompanied by proper animal management and regular vaccination programs against economically important diseases.

Intervention option 3.2. Analysis of drug quality, microbial resistance, and evaluation of effectiveness of selected vaccines

Assessing and generating information on handling and quality of different veterinary drugs available on the market/used by livestock producers will help to enforce appropriate regulatory measures by concerned bodies. Moreover, assessing effectiveness of selected vaccines in collaboration with NVI will help to undertake corrective measures.

Intervention option 3.3. Expansion of veterinary clinics and strengthening the existing ones

Expanding the coverage of veterinary clinics to enable farmers obtain the services in their possible close proximity will help to improve performance of the livestock sector and farmer livelihoods.

Strategic problem 4:- Inefficient milk marketing system

Inefficient milk marketing system was reported to be the other major problem affecting dairy farmers mainly in Girar-Jarso District. Some of the important aspects emphasized by farmers and district level livestock production experts related to milk marketing include lack of binding rules and regulations in milk marketing, lack of pricing system based on milk quality standard, involvement of many middle actors in the milk value chain, concentration of milk processing plants away from potential dairy shed areas and weakening of available dairy cooperative unions such as Selale Dairy Union. The combined effect of these factors has resulted in high gap in milk price between the farm gate and the terminal market (at least a double of the farm gate price at terminal market), adulterations at various stages with the consequent low milk quality, and limited bargaining power by farmers. Therefore, the following intervention options have been suggested for possible action:-

Intervention option 4.1. Establish regulation for standard milk marketing system (pricing based on quality)

The lack of rules and regulations for standard milk marketing has resulted in poor quality of milk supplied to the market due to adulterations at various stages of the value chain. In the process, genuine actors including farmers are always at a

disadvantage as prices paid to farmers are flat whether the product is adulterated or not—due to lack of robust testing procedure and facility at field level. Therefore, establishing regulation for standard milk marketing is highly essential.

Intervention option 4.2. Regular testing of milk quality and awareness trainings to producers on quality milk production

Intervention option 4.3. Encourage establishment of more milk processing plants in the potential dairy shed areas in order to minimize involvement of the middle actors and ensure fair benefit by producers

Intervention option 4.4. Assess the problems and provide the required support (technical, material, etc.) to strengthen available dairy cooperative unions

The problems facing the available dairy cooperatives (mainly in Selale) need to be further assessed and different interventions should be enacted to strengthen their technical, managerial and physical capacities.

Intervention option 4.5. Assess and generate policy briefs on the effect of importation of powder milk on domestic milk production and marketing

Smallholder dairy farmers in the major dairy shed areas like Selale are complaining that they are not fairly benefiting from the prevailing milk marketing system and sometimes for the lack of market for milk. Hence, effects of importing powder milk on domestic milk production and marketing should be assessed to provide appropriate policy recommendations.

Strategic problem 5:- Shortage of pure water supply

Farmers in all the study areas described shortage of pure water supply as the major problem affecting both human being and livestock especially during the dry season. Deforestation and expansion of farming to the edge of water points with the consequent drying-up of rivers, and streams during the extended dry season and lack of alternative water sources are the major factors affecting availability and water quality in the study areas. This can result in high loss of condition and productivity of animals, dependence on stagnant and unclean water resources that pre-dispose the animals to water-borne diseases and parasites such as leech and wastage of farmers time and energy in moving animals long distances in search of watering points. Hence, the following intervention options have been suggested for possible action:-

- Strengthen watershed based natural resource conservation (NRC);

- Minimize disturbances—deforestation, ploughing—around available water points—re-enforcement with additional afforestation programs—while integrating with other income generating activities such as apiculture;
- Develop alternative water sources such as boreholes, and diversion of perennial rivers where applicable; and
- Explore why rain water harvesting has failed to sustain and devise strategies for possible revitalization

Strategic problem 6:- Low awareness of farmers on improved livestock technologies

Majority of farmers in the study areas have limited awareness on available livestock technologies which resulted in low adoption of improved technologies. Moreover, most research results published on different scientific publications have not been properly extracted, synthesized and prepared in easily understood communication materials to facilitate knowledge transfer. For instance, there is no any training manual published in easily understood local languages for use as a training guide by livestock production/extension experts and other development partners. Hence, the following intervention options have been suggested for possible action

Intervention option 6.1. Support regular trainings and arrange other knowledge sharing programs (cross-site visits, field days, etc.) while ensuring fair representation of the appropriate target groups (women, youth, etc.)

Intervention option 6.2. Preparation and publication of research results and best practices in easily understandable communication materials for experts, DAs and farmers

Applicable livestock research results should be published to facilitate dissemination of information to various target groups.

3.5.4 Cause-effect analysis of NRM problems

In addition to many of the problems and possible remedies that have been identified and presented in the preceding chapter of NRM, this section presents in-depth analysis of the causes and effects of problems along with recommendations. Table 16 illustrates the causes and effects of NRM problems. The most important problems identified were lack of irrigation water, early cessation of rainfall, lack of alternative energy source, deforestation, soil erosion and soil fertility decline, absence of farm machineries and improved implements, and others. Details of these problems and proposed intervention options are also presented in subsequent sections:

Table 16. Natural resource related cause-effect analysis of problem

Rank	Problem	Causes	Effects	Proposed solutions	Opportunities available	Actors
1	Soil fertility depletion	• Soil erosion • Crop residue removal • Deforestation	• Natural resource degradation • Soil acidity and nutrient deficiency • Low yield	• Conservation measures • Application of organic and inorganic soil amendments.	• Resources for conservation measures • Soil fertility restoration.	EIAR, CGIAR, MoA, NGOs, farmers
2	Shortage of mineral fertilizer supply	• Inadequate supply.	• Low yield and production.	• Supply of fertilizer in sufficient amount and on time.	• Farmers' readiness to purchase.	MoE, private companies
3	Unreliability of rainfall/climate change	• Climate change • Degradation of natural resources.	• Land degradation • Lower yields/crop damage and failure. • Increased risk of food and water shortage	• Rehabilitation of natural resources, i.e. improving forest cover • Introduce early maturing crop varieties; • Expand irrigated agriculture	• High potential in water resources • Availability of early maturing crop varieties	EIAR; MoA; MoE; EPA; HLIs,
4	Shortage of irrigation water, and management	• No dams or reservoir to store water • Improper irrigation methods and water management	• Low yield of irrigated crops • High water loss	• Construction of reservoirs and dams • Introduce proper irrigation methods	• High potential in water resources • Availability of research institution	MoE, farmers, NGOs, Water resource institutions
5	Shortage of potable water	• Unreliability of rainfall • Degradation of natural resources	• Insufficient availability of water for humans and livestock	• Rehabilitation of natural resources, including forest cover	• Springs, ponds and rivers that can be developed for different purposes.	Water resource institutions, NGOs,
6	Deforestation	• Cutting of trees • very low establishment of planted seedlings • Conversion to farmland	• Soil erosion • Climate change • Decline in agricultural productivity	• Afforestation and reforestation • Development and implementation of forest management plans • Participation and benefit of forest users • Clear and respected tenure and use rights	• Degraded lands for reclamation and forest cover.	MoE, EPA, NGOs, UNEP
7	Absence of improved farm implements and	• No introduction at all	• High workload on oxen and farmers • Low yield and quality	• Introduce suitable farm machineries and implements.	• Farmers' willingness to purchase machineries • Availability in markets	MoE, EIAR, private companies, NGOs, HLIs, farmers and

	machineries		• Low efficiency of work			farmers' unions.
8	Land slide	• Steep topography, • Inappropriate land-use torrential rainfall	• Loss of properties (crops, livestock, houses) and human lives	• Proper land use-avoid cultivation of steep sloppy lands • Resettlement program	• Farmers are willing to resettle in other suitable areas.	Regional government, MoE, farmers
12	Surface water logging on Vertisols	• Inherent soil character	• Low yield • High load on oxen	• Introduce new BBM • Continue researching on more suitable type of implement	• Availability of BBM on market • Opportunity for double cropping • Large area of potential land covered by Vertisols	
13	Problem of BBM adoption	• Limited supply of BBM • Heavy for oxen • Requires more labor and time • Requires technical knowhow • High price of BBM	• Low adoption • Less diversified cropping system	• Introduce suitable and low cost implement • Train DAs and farmers technically for appropriate BBM usage and BBF layout on different slopes of fields	• Large area of potential land covered by Vertisols • Opportunity for double cropping • Availability of high rainfall • Large number of farm households on Vertisol areas.	
14	Lack of alternative energy source	• Absence of alternative improved energy sources.	• Deforestation • Use of manure and crop residues for energy instead of using for soil fertility	• Supply electric power • Introduce energy saving stoves • Introduce multipurpose trees • Expand solar power and biogas technology	• Availability of energy saving stoves in the market • Availability of seedlings of multipurpose trees • Availability of electric power lines in the vicinity.	• Agriculture offices, Ethiopian Electric Power Corporation, • NGOs (e.g. GIZ), zonal and district administrative offices

Problems and interventions in NRM

Problem 1: Soil fertility degradation

Although loss of soil due to wind erosion is not underestimated, loss of topsoil due to water erosion is the most serious form of land degradation. The severity of erosion on reddish-brown soil is higher than Vertisols, because Vertisols are lying in relatively plain lands. Soils on steep slopes are prone to erosion due to their topographic position and very low soil organic matter content. Farmers consider that Vertisols is relatively fertile but difficult to work due to water logging problem as well as its unique physicochemical properties. On the other hand, most of the soils other than Vertisols have low water holding capacity, which require long rainy season to satisfy the needs of the growing crops. Overall, a declining trend is observed in soil fertility.

Rainfall is the most important climatic factor in determining areas at risk of land degradation and potential desertification. Rainfall plays a vital role in the development and distribution of plant life, but the variability and extremes of rainfall can lead to soil erosion and land degradation. The interaction of human activity on the distribution of vegetation through land management practices and seemingly unfavorable rainfall events can make land more vulnerable to degradation. These vulnerabilities become more acute when the prospect of climate change is introduced. Rainfall and temperature are the prime factors in determining the world's climate and therefore the distribution of vegetation types. There is a strong correlation between rainfall and biomass since water is one of primary inputs to photosynthesis.

Land degradation aggravates CO_2-induced climate change through the release of CO_2 from cleared and dead vegetation and through the reduction of the carbon sequestration potential of degraded land. Generally, high temperatures and low precipitation in the dry lands lead to poor organic matter production and rapid oxidation. Low soil organic matter content leads to poor aggregation and low aggregate stability leading to a high potential for wind and water erosion.

Land degradation is also a national challenge, substantially affecting agricultural productivity in the country, especially serious in the highland parts of the country where human and livestock pressure is high. The impact of land degradation has put at risk the livelihoods, economic well-being, and nutritional status of several people in the country. Land degradation adversely affects ecological integrity and productivity of large areas of land, or landscapes under human use.

Intervention measures

Sustainable agricultural practices can help maintain or improve the productivity of both rain-fed and irrigated agriculture. Production could be increased substantially by restoring and enhancing the productive capacity of soils in an economic and ecologically sustainable way. Thus, unless appropriate amendment measures are taken, the productivity of soils will further decline. In the context of the problems, the following intervention options have been suggested for possible consideration:

Mitigate severe topsoil erosion: This can be achieved through interventions at the individual farm level as well as through large-scale community and regional projects in targeted areas. It would be necessary to set minimum-requirement for soil and water conservation measures on cultivated lands, i.e., primarily for lands that need to be protected from soil erosion to achieve immediate and sustainable food security.

Combat nutrient depletion and strengthen plant nutrient management: The principal fertilizer and plant nutrient management activities include adjusting fertilizer application to needs based on the principle of balanced fertilization; judicious use of fertilizers through soil test crop response fertilizer recommendations; averting nutrient leaching; use of slow-releasing fertilizers; e) test and compare the new fertilizer products (NPS, NPSZn, NPSB, and NPSZnB) under field condition on different soil types and crop types in comparison to DAP and Urea; and integrated soil fertility management, i.e. the combined application of organic and inorganic fertilizers for a sustainable soil health and agricultural productivity. Besides, research on soil test crop response fertilizer recommendations needs to be strengthened.

Enhance application of organic and inorganic fertilizers: Integrated soil fertility management, i.e. the combined application of organic and inorganic fertilizers is an alternative soil fertility management approach for a sustainable soil health and agricultural productivity. Fertilizer is one of the most useful agricultural inputs to improve the fertility of soils and yields of crops per unit area. Based on trial results, most soils are found to be responsive to fertilizer. Generally, fertilizer is the most purchased farm inputs, which is applied mainly for cereals. According to the experience of farmers, blanket recommended fertilizer rate does not consider differences in soil fertility within a certain locality. For instance, soils around the homestead receive manure and wastes which makes them more fertile, and as a result, it is not necessary to apply fertilizer equally to all crop and soil types. For crops grown on soils that do not receive compost and/or manure, fertilizer should be applied based on the fertility of soils. Proper use of packages, including fertilizer, improved seeds, and agronomic practices may enable farmers to achieve substantial yield gains, if they can be suitable for particular localities.

Applying substrates like compost, manure, crop residues and other organic materials are among the major organic nutrient sources that replenish soil with different plant nutrients. The major sources of manure include cow-dung, equine and sheep droppings, and farmyard manure, household wastes, green wastes and ash for compost preparation. Farmers have also well understood that the use of integrated soil fertility management practices is very effective in terms of improving the overall soil biophysical and chemical properties, but use of compost or manure is very limited due to other priorities. For example, the crop residues are used as animal feed, cash income and thatching, and over 80% of the manure is used as household energy source for cooking and heating. The misuse of such resources has severely aggravated the depletion of soil organic matter, and as a result the retention of plant nutrients and water has been decreasing. The efficiency of applied nutrients has also been very low because of the depletion of soil organic matter. Compost and manure are mostly applied around the homestead; farmlands far from the homestead do not receive manure and compost because of lack of transport and high labor demand.

Refine fertilizer recommendations based on crop varieties and soil types: Crop, variety and soil type affect the rate of application of fertilizer. Cereals, for example, are the first priority crops, which receive the highest share and rate of fertilizer compared with other types of crops grown in the area. Soil type is another factor affecting fertilizer rate. For example, reddish brown soils (Nitisols) receive higher fertilizer rate than Vertisols and Cambisols. Based on the soil and crop type a blanket application of 10-20 kg P and 32-41 kg N ha^{-1} is used in the form of DAP and Urea, and in some cases 20 kg P and 64 kg N ha^{-1} is applied for improved varieties of tef and wheat. In some areas, the equivalent of these is used in the form of NPS, which is a blend of nitrogen, phosphorus, and sulfur. In most cases, both N and P fertilizers are applied during planting. Virtually, the application of fertilizer to oil seeds and grain legumes is very rare. Although access to commercial fertilizer is not a big problem, the price increase from time to time is becoming the major limitation to buy and apply the required amount of fertilizer. One of the reasons for this is that the cost of farm inputs and outputs are not balanced.

It should also be emphasized that the response of soils to fertilizer application is poor in North Shewa zone of Oromia region. This requires in-depth study on soil biophysical and chemical properties, as soils in North Shewa are not as productive as other areas of the country even with application of modest rates of fertilizers. Hence, greenhouse and field trials need to be carried out using missing and complete element technique for macro-and micronutrients. In addition, other factors may limit the

responsiveness of soils and crops to application of fertilizers which need further investigation.

Improve crop rotation practices: The alteration of crop species in time has long been known to increase the productivity of land and yields of subsequent crops. In this respect, annual and perennial leguminous crops are low input break crops. Rotation is also effective to lessen the incidence of pests, particularly soil-borne diseases. Farmers explained that continuous cropping of cereals year after year on the same farmland significantly decreases yields of crops. On reddish brown soils, they grow barley/wheat followed by faba bean or field pea, while on black clay soils (Vertisols) faba bean, chickpea and lentil are used as break crops for tef and wheat. If a farmer considers that the soil is better in the fertility status, wheat, tef and barley can be grown without rotation for some years. In general, the rotation practice to be followed in the study areas, especially, on Nitosols is planting cereals (barley- tef - faba bean/field pea-wheat/barley) after legumes. On Vertisols, tef/wheat–faba bean/ chickpea can be practiced. In some cases, farmers in some areas also practice barley - chiflik – barley.

Improve multiple cropping system practices: There are no well-established cropping systems such as alley cropping, strip cropping, and intercropping systems which can be used for soil and water conservation purposes, and other multiple cropping systems such as intercropping and double cropping practices. Intercropping, which maximizes resource use efficiency, is one of the cropping systems to increase agricultural productivity, particularly in areas where land holding per capita is decreasing. The components of the intercrops should be different crop species. Among the three main types of intercropping systems, i.e. mixed, row and strip, which differ greatly in their proportion (Trenbath, 1983; Getachew *et al*., 2008), mixed intercropping is practiced in some selected crops. Moreover, improving crop varieties for nutrient use efficiency; use of cover and green manure crops and; preventing bare fallow land are among improved soil and crop management practices for sustainable soil and crop productivity.

Follow improved fallowing and crop residue management: According to the experience of farmers in the study areas, land was not scarce and fallowing was used extensively before three decades. Currently, very few farmers use this practice and its duration is very short, mostly one to two seasons. The usual practice of fallowing was affected during land reform when land was shared among farmers to own their land depending on their family size.

Even though most of the farmers are aware of the importance of retention of crop residues and stubbles as covers in restoring the fertility of soils, only some part of the stubble is left on the land and the greater portion of it is used for thatching purpose, particularly barley residues. The residues of pulses are preferred by farmers to improve the fertility of soils, yet they are mainly used for animal feed. The straw of tef is mainly used for animal feed and as a subsidiary for house construction. Farmers of the study areas do not practice other soil fertility management practices such as green manure and mulching.

Reclaim acid soils through liming: Soil acidity and associated low nutrient availability such as phosphorus, potassium, calcium, and magnesium are major constraints to crop production in acidic soils of the humid tropics. In Ethiopia, a huge area of cultivated land (~40.9 %) has been affected by soil acidity. Calcium is the dominant base among the exchangeable cations and keeps the soil neutral to alkaline in reaction. In situations where the calcium ions are lost by leaching and are not replenished, the hydrogen ions (H^+) occupy their positions on the exchange sites making the soil acidic in reaction..

Management of acid soils should emphasize strategic research, integrating soil and water management with improved germplasm to generate prototype and environmentally benign technologies for sustained food production within a framework of appropriate socioeconomic and policy considerations. Such technologies need to focus on: organic matter management in acid soil; erosion control in highlands; and reclamation of acid soils. Analysis of relationships among policies and land-use strategies will be made to assess the potential impact of improved technologies on production and the environment.

Liming is a desirable practice where soil is highly acidic and where multi-cropping involving acid sensitive crops is adopted. Lime improves base saturation and availability of Ca and Mg. Fixation of P and Mo is reduced by inactivating the reactive constituents. Toxicity arising from excess soluble Al, Fe and Mn is corrected and thereby root growth is promoted and uptake of nutrients is improved. Liming also stimulates microbial activity and encourages nitrogen fixation and nitrogen mineralization and hence, legumes can highly benefit from liming.

A substantial number of plant species of economic importance are generally regarded as tolerant to acid soil conditions. Many of them have their center of origin in acid soil regions, suggesting that adaptation to soil constraints is part of the evolutionary process (Somani, 1996). The selection of varieties or species, which perform well at high aluminum saturation levels and thus need only a fraction of the normal lime requirement, is of great practical importance. In summary, the following intervention

measures are suggested to manage soil fertility and plant nutrients, and sustain agricultural productivity in the long-term.

Enhance conservation tillage/minimum tillage practices: Maintenance of satisfactory level of SOM is necessary for sustainable agro-ecosystems. This practice can be adopted in areas where the farmlands are steep slope and soil erosion due to water is a major problem.

Improve buildup of soil organic matter. Organic matter is a major contributor to soil fertility. Sequestering CO_2 into the soil through the application of biochar and biochar-compost mixes may improve the soil organic carbon content.

Problem 2: Quality and shortage of mineral fertilizer supply

Urea and DAP were major sources of nitrogen and phosphorus nutrients for major crops, mainly cereals. Besides, the new fertilizer formulations containing nitrogen, phosphorus, sulfur and some micronutrients have been introduced since the last two years. These include nitrogen + phosphorus + sulfur (NPS), NPS and zinc (NPSZn), NPS and boron (NPSB), and NPSZnB.

According to farmers' judgment, even though NPS has been effective, it cannot surpass DAP in terms of plant growth and yield. The reason for this is that DAP contains more phosphorus than NPS fertilizer. Thus, if farmers are provided with DAP and NPS with equal price, their first preference is DAP. Most farmers still consider DAP is more advantageous in terms of yield, when it is applied in recommended dose, than other fertilizer types, but its price is consistently increasing from year to year, which is unaffordable by the majority of farmers. Moreover, DAP is not currently available in the market. This implies that further on-farm research and demonstration activities will be necessary to verify the significance of NPS, in comparison with DAP. The other NPSZn, NPSB and NPSZnB fertilizers have not been yet used by farmers. There is no soil test based fertilizer recommendation in the surveyed districts.

The cause of shortage of chemical fertilizers is inadequate supply. There are no different fertilizer companies which are involved in the distribution and retailing of fertilizers. The shortage of fertilizer supply in both types and quantities may bring about insufficient and unbalanced fertilization, poor plant growth and ultimately results in low yield with poor nutritional quality.

Proposed solutions

- Test and validate new fertilizer products based on the new soil fertility map of each district issued by ETHIOSIS; and

- Strengthen and diversify input suppliers: Expansion of fertilizer suppliers at each level may improve the supply of fertilizers and other inputs in the required amount and types of fertilizers. The delivery of fertilizers for farmers needs to be on time.

Problem 3: Climate change/unreliability of rainfall

Since recent times, unreliability of rainfall is mainly the major problem in many parts of the country because of the unprecedented climate change. Climate change is defined by high atmospheric carbon dioxide (CO_2) concentrations ($\geq$ 400 ppm); increasing air temperatures (2–4 $^{\circ}$C or greater); significant and/or abrupt changes in daily, seasonal, and inter-annual temperature; changes in the wet/dry cycles; intensive rainfall and/or heavy storms; extended periods of drought; extreme frost; and heat waves and increased fire frequency, is expected to significantly impact terrestrial systems, soil properties, surface water, and stream flow (Patterson *et al*., 2013); groundwater quality, water supplies, and terrestrial hydrologic cycle (Pangle *et al*., 2014); and, as a consequence, affecting food security and environmental quality. A study by Knox *et al*. (2012) indicates that climate change will impact productivity of major crops in Africa. They have estimated that mean yield change for all crops is -8% by the 2050s with strong variations among crops and regions. For instance, evidence of yield reduction up to -40% is detected for some regions of Africa (Knox *et al*., 2012; Sultan, 2012).

The increase in anthropogenic greenhouse gases emissions will result in global climate change. Population pressure, poverty, and the lack of policy measures are the main causes, which exacerbating environmental problems. The expansion of agriculture into marginal areas and clearance of natural habitats, such as forests and wetlands has been a major driving force behind climate variability and land degradation. Degradation of natural resources over the past three decades are the main causes of climate change and threatens the livelihood of many people.

Agriculture is considered as the most weather-dependent of all human activities (Hansen 2002), hence climate is a primary determinant for agricultural productivity. Climate change can affect agricultural production and soil and water conservation. Thus, one of the most direct and threatening impacts it may have on human societies is the potential consequences on global crop production. Drought-affected areas will likely increase in extent, and as a result warmer and drier conditions may lead to a reduced length of growing season with detrimental effects on crops.

In many African countries and regions, agricultural production, including access to food is projected to be severely compromised by climate variability and change. The area suitable for agriculture, the length of growing seasons and yield potential,

particularly along the margins of semi-arid and arid areas, are expected to decrease. This would further adversely affect food security and exacerbate malnutrition in the continent. In some countries, yields from rain-fed agriculture could be reduced by up to 50% by 2020 (IPCC, 2007).

The resilience of agro-ecosystems is likely to be exceeded by an unprecedented combination of climate change, associated disturbances, and other change drivers. Increases in the frequency of droughts and floods may affect local crop production negatively, especially in subsistence sectors. Crop productivity may decrease in seasonally dry areas, which would increase risk of hunger, malnutrition, and consequent disorders, with implications for child growth and development

Proposed solutions

- **Improve adaptation procedures and risk management practices**: Sustainable development can reduce vulnerability to climate change by enhancing adaptive capacity and increasing resilience. According to IPCC (2007), adaptive capacity is the ability of a system to adjust to climate change including climate variability and extremes to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. For instance, adaptations such as crop varieties and planting times as well as adaptation measures in land-use planning may enable to maintain crop yields at or above baseline yields for modest changes in climate;
- **Enhance knowledge of climate change impacts on agricultural productivity**: This is very crucial to inform policies and to support adaptation strategies that may counteract the adverse effects, especially in vulnerable areas of the country. Overall, natural resources must be safeguarded; science and technology should be used to improve the environment; environmental education is essential; and environmental research should be promoted;
- **Strengthen multidisciplinary research approach on mitigation and adaptation of climate change:** These include improved germplasm, efficient soil and water management practices including water harvesting, sustainable land management, water stress, disease and insect pest control, etc., which are adaptable to the prevailing climate change; and
- **Family planning**: Strengthen implementation of policies for human population, development and utilization of natural resources

Problem 4: Deforestation

Cutting of trees, very low establishment of planted tree seedlings, and conversion of forest and bush lands to agricultural land due to population pressure are the major causes of deforestation. The change in the land use system and disruption of the ecological balance has been the driving force for accelerated soil erosion, climate change and decline in agricultural productivity. The experts in the surveyed districts remarked the low budget allocation to the sector and they mentioned that only few

universities had incorporated the natural resource study program in their educational curriculum in spite of its critical importance to the country.

Proposed solutions

- **Increase afforestation, reforestation, and area enclosure and forest management**: Without proper management, planting of tree seedlings alone every year cannot be an indicator and measurement of expansion of forest areas in the country. Hence, proper management and protection of planted seedlings is a prerequisite for improved establishment and growth of forest trees. This will enable farmers to rehabilitate degraded lands and improve the environment through the planting of trees;
- **Development and implementation of forest management plans;**
- **Increase participation and benefit of forest users;**
- **Establish clear and respected tenure and use rights:** If farmers have the right to own and use forest areas they will develop sense of ownership, and take responsibility to replace cleared areas and manage planted tree seedlings. This is one of the mitigation measures to sustainably improve the environment and ecosystem services; and
- **Promote crop intensification:** Agricultural intensification on the existing cultivated lands will significantly minimize the clearing of forest areas and cultivation of marginal lands. Multiple cropping systems, such as double cropping are among crop intensification approaches to increase crop productivity per unit area, particularly in areas where land holding size per capita is decreasing.

Problem 5: Surface water logging on Vertisols/poor surface drainage

The inherent soil physical and chemical properties of Vertisols are the main cause of surface water logging. Vertisols have high soil water content at field capacity, low hydraulic conductivity, and low infiltration rate, which cause high surface water logging problem during the main rainy season, which constitutes 70% of the annual rainfall. In spite of these characteristics, Vertisols are the dominant soil types in West Shewa including southwest Shewa and North Shewa covering circa 29% and 26% of the land mass, respectively.

Proposed solutions

Strengthen supply and use of BBM: During the 1980s, the joint Vertisols project which was launched by inter-institutional and multi-disciplinary team was able to release, demonstrate and popularize a package of technology in Dendi district (West Shewa) and Chefe Donsa (East Shewa). The major component of the package was BBM. The other components of the package include short season wheat variety, planting date, seed and fertilizer rate and pest control. The BBM is used to drain excess surface water. There are also technical parts associated with the BBM, which are fixing of the BBM on two local Maresha to be pulled by oxen and laying of the BBF on 0.6-1% slope gradient on the field. During the active time of the project, the adoption level

had been good. But, through time farmers were unable to bear the cost of the implement and the oxen due to the heaviness of the instrument. Following the feedback, a new light weight version of the BBM, named AYBAR was developed. The team recognized the high demand of AYBAR during the study. Therefore, the first option of the solution should be to improve the supply of AYBAR. The follow up, which is the crucial part in the expansion of the technology, should provide DAs and farmers with appropriate training about the laying and orientation of the BBF on the field within the recommended slope range

Develop alternative implement including innovations: Although several new ideas are existing and evolving, the study team suggests one of the old type and effective technique of surface drainage method, which is known as mole drainage. Mole drainage involves molding of the subsoil to form porous drainage pipe laid at some depth, i.e., below the local *Marsha* plow depth, which is continuous up to the outlet, and parallel to the surface of the field. It acts as sub-surface drainage system. A mole is a missile shaped cylindrical solid iron. Mole drain can stay functional up to five years and do not initiate wet land like BBM. In this option, to undertake the following is most important:

- designing an appropriate mole drain that can be pulled by an average oxen power,
- testing the best moisture level to construct the best mole drain, and
- testing the effectiveness of the mole pipe in draining excess surface water

Strengthen selecting crop and crop varieties more tolerant to waterlogging than the existing ones. The current crop varieties under use are becoming susceptible to wilt and rust diseases. This implies the requirement of continuous research to overcome the dynamic challenges in crop production. Moreover, the effort to select and improve adaptable rice varieties for waterlogged Vertisols should be intensified.

Strengthen the selection and adaptation of high value crops such as spices and vegetables.

Problem 6: Limited adoption of BBF

The causes of the problem are limited supply of BBM; unsuitability to oxen; consumption of more labor and time; requirement of technical knowhow; and high price of BBM/AYBAR. The technology needs high oxen draft power compared to tef cultivation, which is the normal farmers practice on Vertisols. Moreover, it requires more production cost per hectare for double cropping practice compared to sole tef production. Double cropping will only be successful if the second crop most of the time chickpea is doing well. The approximate cost benefit estimation explained that

even if the second crop is doing well, the advantage over the normal practice is not significant. The risk of failure of the second crop is also high due to climate change and early cessation of main season rain. In addition, BBM needs a technical knowhow for appropriately laying out and orienting it with the recommended furrow gradient on different surface slope fields which otherwise results in low crop productivity. The high price of BBM has contributed to the low adoption of the BBM. Thus, all the above-mentioned causes added up for the low adoption of the technology.

Low adoption rate of BBM and risk of disease and insect pest breakout in sole cropping system are among the effects of the problem. This is mainly associated with low diversity of crops and cropping system and losing the advantage, which would be gained by crop rotation, especially the advantage that would be gained by inclusion of pulses in the crop rotation such as improving soil fertility.

Proposed solutions

- Improve supply and cost of BBM/AYBAR technology; train DAs and farmers on BBM operation and layout of BBF with the recommended furrow gradient on fields with different surface slopes;
- Carryout effective research to refine the appropriate furrow gradient for BBF land preparation, i.e. removal of excess surface runoff without significant soil loss/erosion. So far, there is no appropriate recommendation on BBF gradient; and
- Conduct research to confirm the economic benefit gained by using BBF in association with double cropping—producing wheat plus chickpea or other suitable pulse crops—compared to producing tef only. Here, one should also be able to determine the trade-offs between tef production and wheat and pulses production with BBF.

Problem 7: Shortage of irrigation water and management

The main causes of the problem include absence of or limited dams or reservoirs to store water; improper irrigation methods; and unavailability of improved technology package for small-scale irrigation schemes (SSIS). This has resulted in low water and land productivity, high water loss, and low yield of irrigated crops.

Proposed solutions

- **Strengthen construction of reservoirs, check dams and farm ponds:** Here, getting a piece of land for constructing farm pond is difficult in the current situation. Therefore, constructing check dams in the stream channel at appropriate places for intake could be a realistic option. The check dams also help to recharge the ground water;
- **Exploit ground water resources**: Availability of simple ground water pumps will enhance the practicality of this option;
- **Apply available irrigation technologies that minimize water loss such as drip irrigation and those irrigation technologies suitable to the agro-ecology**: Full package technology for SSIS

should be developed after comprehensive research work on different crops, especially for those crops used by the SSIS farmers. To acquire efficient irrigated agriculture and minimize water loss, the following measures should be undertaken:

- Determine crop water requirements of irrigated crops for efficient water use and enhanced yield;
- Employ CROPWAT and other suitable models to get quick and appropriate water requirements for irrigated crops;
- Develop fertilizer recommendations for major irrigated crops;
- Improve water conveyance system, i.e. by using lined canal and flexible cheap fabric plastic pipes; and
- Train DAs and farmers on how to measure the amount of irrigation water to be supplied to different crops in the field. This means that the irrigation water supply should be based on the water requirement of each crop.

Problem 8: Absence of row-planters and threshers for tef and wheat

The introduction of improved farm machineries and implements and their demonstration is very limited or absent at all. This has brought about high workload on oxen and farmers, and resulted in substantial loss of crop yields and low grain quality. Broadcast sowing resulted in high seed rate and decreased crop yields compared to manual row planting. Row planting could only be practical when suitable row planter is introduced. The row planter minimizes the time to be spent in manual row planting, increase crop yield and decrease seed rate for planting.

Proposed solutions

- Introduce and demonstrate suitable farm machineries and implements especially, row planter and thresher for tef and wheat;
- Train farmers and DAs on how to use new farm machineries and improved implement; and
- Establish maintenance center for farm machineries. Once farm machineries are introduced and distributed widely among farmers, setting up a service center is important to fix any defect or provide farmers with spare parts. It may also help to create job opportunities for the young people in rural areas.

Problem 9 -Land slide

Agricultural land shortage due to population pressure is the root cause of the problem. Thus, landslide occurred in some districts, such as North Shewa Zone of Oromia Region, when hilly lands were cultivated for crop production. The effects of the problem are damage or loss of human and animal lives, assets, and vegetation including cropped lands.

Proposed solutions

- Resettle farmers to other safe areas where productive agricultural land is available;
- Avoid using hilly slopes for crop production without appropriate soil and water conservation management practice;
- Implement land-use policy;
- Introduce suitable practices for hill slope agriculture, such as bench terrace combined with fruit trees, bench terrace with perennial tree or tree cash crops. Research institutes should work in selecting suitable fruit/cash crop varieties and the associated land use for the agro-ecology where land slide is a problem; and
- Adaptation of multipurpose grass species and fast-growing tree seedlings on soil bunds as a biological soil and water conservation measures.

Problem 10: Lack of alternative energy sources

Because of the absence of alternative energy sources in rural areas, main sources of energy for cooking and heating are woods and animal manure. This has exacerbated the deforestation of both natural and human-made forests. Besides, manure is mainly used as energy source instead of being returned to the soil for replenishing soil fertility.

Proposed solutions

- **Increase fuel efficiency of major fuel-consuming household devices to reduce overall fuel requirements:** The focus could be on smallholders' cooking stoves, which in the longer term could extend to other devices. Fuel-efficient stoves, such as the "Gonze", can save up to 66% energy compared to the three-stone stoves currently used. Efforts were underway by the Ministry of Mines and Energy along with various NGOs and donors to distribute them at low cost;
- **Strengthen rural electrification:** Expansion of electricity in rural areas of the country will ease the burden on clearing of forests and reduce natural resource degradation. Moreover, the manure which is mainly used as a source of energy will be utilized to ameliorate soil fertility;
- **Expand solar power and biogas technology**: Initiate a national program to ensure rural kebeles have adequate local sources of fuel other than manure for basic household requirements; and
- Initiate household fuel wood projects, and ensure that farm households plant agro-forestry trees around homesteads and farm boundaries, to provide fuel wood, livestock feed and help reduce erosion.

4. Conclusion and Ways Forward

4.1 Conclusions

In this study, the various social, biological, environmental and policy factors affecting agricultural productivity, environmental sustainability and the overall farmers` livelihoods of the North, West, and Southwest Shewa Zones of the Oromia have been identified and documented. Even though in-depth case analysis has been conducted in selected districts, the findings could apply to other districts as well because of context similarity. Moreover, recommendations proposed are applicable not only to all the AGP II districts where this study made a focus, but also to other districts in the country with similar socio-economic, agro-ecological and farming system contexts.

Though efforts have been made to increase production and productivity of smallholder farmers through the use of improved agricultural technologies in AGP II beneficiary districts, the production and productivity intended to be achieved is far from reality. There are a number of interplaying challenges from physical technology to farmers' capacity and capability to use full package of the technologies to boost production and productivity. Most importantly, there is inadequate use of agricultural inputs in crops, livestock, NRM and other sub-sectors of agriculture. Though the extension system is making its maximum effort, the farmers have not yet adopted complete package of the technologies due to a number of factors. The reasons most farmers mentioned for not using or adopting complete package of technologies were inadequate availability of improved technologies, high prices of the, and lack of initial capital to invest for purchase of inputs. The other challenges also include climatic change expressed through drought and unfavorable rainfall variability. Frequent drought occurrence has been more apparent since the last decade than the past. Particularly, the short rainy season (belg) was irregular for some time, but since the last four years belg agriculture has been impossible because of the total cessation of short season rain fall. The area covered by irrigation is also very small due to limited investments on irrigation agriculture.

In general, the study has identified the following major problems hampering agricultural productivity and production. The major socio-economic problems identified in the study areas include inadequate access and coverage of improved agricultural technologies, limited access to credit and/or complicated modality of the available credit schemes, high costs of inputs, land shortage, youth unemployment, inefficient health services, and shortage of potable water.

The major factors affecting crop production and productivity in the study areas include occurrence of various crop pests and diseases, limited knowledge on input use and

saving concept, shortage and erratic rainfall distribution, land degradation and poor soil fertility, and high turnover of agricultural experts and DAs. The livestock sector in the country in general and in the study areas in particular is also constrained by shortage and poor quality of available feed resources, inadequate supply and high cost of improved crossbred heifers, prevalence of various livestock diseases, inefficient marketing systems for , and low awareness of farmers on available livestock technologies.

The major problems identified with respect to natural resources management include soil fertility depletion, shortage of mineral fertilizer supply, shortage of irrigation water, deforestation, absence of improved farm implements and machineries, surface water-logging on Vertisols, limited adoption of BBM technology, shortage of alternative energy sources and landslide in some areas. The causes, effects, possible intervention options, available opportunities and the major actors to be involved are also provided against each of the identified problems for subsequent actions.

4.2 Ways forward

Future research and development planning by AGP II and other programs should consider the identified problems as front-liners to design projects and further research initiatives. Even though a number of problems have been identified and potential intervention options suggested in view of the current situation, similar assessments will be required at regular intervals, such as every five years, in order to capture emerging issues given the unavoidable dynamism of farming systems. AGP II along with its partners should focus on carefully selected problems for targeted interventions based on the available capacity and priorities of the program within its specified time frame.

Even though efforts have been made to enlist options of recommendations that are believed to address the problems in the context of existing farming systems and farmers' capacities, other intervention options that are thought to be economically feasible, socially acceptable and environmentally sound can also be suggested in the course of project planning and appraisal processes. Participation of key stakeholders including from locations where projects are executed is believed to be crucial in project planning and appraisal phases. This will help to ensure that intervention options can address farmers' problems on sustainable basis and farmers' economic and food security issues will be attained, and their resilience to climate change would be enhanced. In addition to being participatory, the projects to be designed need also to consider the perspectives of gender, nutrition and climate smart green agricultural development. Project beneficiaries need to be properly mainstreamed in the project

document focusing on men, women and youth as all have the roles to play in agriculture.

In the face of frequently emerging climate change and variability challenges on agriculture, especially drought and rainfall variability, priority should be given for investments in irrigation agriculture in areas where there is water potential. Quick assessments of irrigation potential could be made with a team of specialists from irrigation, crop, livestock, social science and other disciplines in locations where an irrigation water potential has been spotted in the districts.

Active participation of key stakeholders is fundamental in the course of project implementation. Actors identified in this document and others should play their roles and make active contributions from the perspective of their mandates. Stakeholder participation is required from project design all the way to monitoring and evaluation stages, including cost sharing, capacity building, advisory and technical backstopping. Robust capacity building initiatives need also be designed in the course of project implementation to ensure that recommendations have been fully implemented and that quality of project outputs have not been compromised for capacity limitation.

There should also be strong monitoring and evaluation system to ensure that project implementation is on the right track. In the course of project implementation, it is suggested to initiate participatory mid-term assessment to identify the problems early and provide corrective measures timely. After project termination, there should also be initiatives to assess impacts, identify and document best practices, and draw lessons for consideration not only in the subsequent phases of AGP II but also beyond. An exit strategy need also be set in place before termination of the project.

Despite details have been provided in the text and in the problem-solution analysis section, the following major recommendations have been figured out with implications for interventions during AGP II period and beyond:

4.2.1 Implications for AGP-II interventions in socio-economic studies

The following key Socio-economic issues have been suggested for consideration during AGP II period and beyond

- Demonstration, scaling-up, promotion and dissemination of packages of improved agricultural technologies for the farmers as per their demands, including package of improved varieties of cereals, pulses, oilseeds, potato and vegetables, agricultural mechanization tools, improved chicken breeds, improved forage crops, fast track animal breeding technologies and others. This should be accompanied by robust capacity building

and experience sharing initiatives associated to the specific technological packages to empower farmers in efficiently making use of technology promotion and dissemination;

- Adoption and impact study of agricultural production technologies in AGP II districts to track the progress of technology promotion and dissemination initiatives, and identify factors affecting adoption status. This study should figure out technology use and impact with gender perspectives;
- Assessment of the extent of access and utilization of rural finance and credit services to small-holder farmers and its influence in improving farmers' productivity, livelihoods and commercialization. Factors affecting farmers' credit repayment ability need also be figured out for designing effective credit system;
- Investigation of the impacts of agricultural extension approaches, tools and techniques on farmers' productivity and livelihood improvements;
- Analysis of the impact of agricultural communication technologies (mobile phone) on enhancing farmers' business orientation, market participation and technology use;
- Assessment of the impact of household's access to rural infrastructure, such as rural roads and transportation, on farmers' input use, market participation and incomes; and
- The study of development needs, challenges and employment opportunities of rural youth and their technology use status.

4.2.2 Implications for AGP-II interventions in crops research

Even though several recommendations have been proposed in the text and crops cause-effect analysis section, the following key intervention options have also been suggested for consideration during AGP II period and subsequent phases:

- Strengthening formal and informal seed multiplication schemes: Seed multiplication should be the first intervention focus of AGP II and other stakeholders. The research system should avail sufficient early generation seed breeder and pre-basic seeds while seed producers should produce sufficient amount of seeds of improved crop varieties. AGP II should make supports to seed multiplication through both formal and informal seed multiplication channels accompanied by capacitating or fostering early seed production by the research system and also capacitating the seed producers to produce sufficient amount of seed and satisfy the demand of improved seeds by farmers;
- Demonstration, popularization and scaling up of the already existing technology packages: AGP II can also support and strengthen the demonstration, popularization and scaling up of already existing crop production technologies. Focus should be given to the use of complete package of the technologies;
- Demonstration and popularization of improved storage structures such as PICS Bags and Metal Silo to minimize post-harvest losses due to storage pests (especially bruchids);
- Demonstration of chemical use and safe handling mechanisms: The research system should focus on training of farmers, development workers, and other stakeholders on proper use and safety of technology packages including chemicals. AGP II can support in bringing all the actors/stakeholders (researchers, chemical companies, traders of

chemicals, BoANR) to solve the problems associated with chemical trading, quality, use and safety;

- Developing high yielding crop varieties that are resistant or tolerant to the already existing and emerging pests: AGP II should keep on supporting applied research activities on pipeline that can reach the farmers in the shortest period of time; for example, technology verification and adaptation trials; and
- Development and generation of climate-smart agricultural technologies in all crops research programs: Development of climate change resilient crop varieties (drought, water-logging, frost, soil acidity, etc.), identification of appropriate crop and crop varieties for irrigation and use of irrigation schemes should be emphasized. AGP II can assist all the actors in this aspect.

4.2.3 Implications for AGP-II interventions in livestock research

The following intervention options have been suggested in livestock research for consideration during AGP II period

- Comparative analysis and enterprise choice study of improved forages with other crops: Tangible evidences need to be generated in order to verify that forages are competitive and better enterprise choices to enhance adoption and use;
- On-farm demonstration and promotion of available feed technologies mainly improved forage crops;
- On-station multiplication of seeds and/or seedlings of released forage varieties.
- Promote and strengthen informal forage seed production and supply scheme using cooperatives and model farmers;
- On-station multiplication and promotion of crossbred dairy heifers in selected AGP II woredas mainly in West and Southwest Shewa Zones;
- On-station multiplication and promotion of improved chicken breeds in selected AGP II woredas;
- Assessment of farmers' milk handling and marketing practices;
- Support trainings and strengthen other experience sharing programs to build awareness of farmers and other stakeholders on improved livestock technologies and best practices; and
- Support preparation and publication of applicable research results and best practices in easily understandable communication materials for ready use by experts, DAs and farmers.

4.2.4 Implications for AGP-II interventions in NRM

While details of recommendations have been presented in the text and problem-cause-effect analysis section, the following key NRM based intervention options have been figured out for consideration during AGP II and its subsequent phases:

- Validation and transfer of technologies for ameliorating soil acidity in AGP-II districts: The issue of addressing acidic soils is one of the main research and development priorities

identified in this survey. Further Research is also required on development of technically efficient, ecologically sound and economically viable management of acid soils: The technical package may involve the use of lime for soil acidity reduction; management of macro- and micronutrients; organic matter management; minimum- and conservation tillage systems; and development of crop and pasture varieties suited to the mixed crop-livestock systems of the highlands. The research results will provide information for farmers' decisions on sustainable land management; develop technologies which increase the productivity of crops; promote the improvement of degraded lands; and monitor changes in soils due to agricultural activities;

- Characterization of the biophysical and chemical properties of agricultural soils in AGP II districts: For instance, soils in Girar Jarso District, North Shewa zone are not as productive as other areas of the country even with the application of optimum fertilizer rates. Hence, in-depth study on soil biophysical and chemical properties is required. This may lead to greenhouse and field experiments using different research methods (e.g. missing and complete element technique for macro-and micronutrients; integrated soil fertility management trials to improve the overall soil health as soil degradation and soil organic matter depletion is severe in the area);
- Test and validate the new fertilizer products containing both macro- and micro-nutrients as per ETHIOSIS map: These include nitrogen, phosphorus and sulfur (NPS), NPS + zinc (NPSZn), NPS + boron (NPSB), and NPS + Zn + B) (NPSZnB) under field condition on different soil types and crop types in comparison to DAP and urea;
- Determination of fertilizer recommendations for irrigated crops along with other agronomic practices for efficient use of nutrients and water and optimum yield;
- Determination and recommendation of crop water requirements of major irrigated crops for efficient water use and enhanced yield;
- Research and development on crop intensification: This includes multiple cropping systems and cropping sequence. Sustainable intensification is the best approach to curb deforestation and expansion of agriculture to marginal lands. Many countries in South-East Asia are best examples in this practice, where their index of multiple cropping is over 150%; and
- Establishing a national data-base for soil fertility and nutrient management: This will help to allow the government, donor agencies, and research and development institutions evaluate their investments, land-use policies and technologies in soil fertility management. Besides, it will allow researchers, agricultural development professionals and farmers to understand and eventually modify land-use practices.

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