Tigray Agricultural Research Institute

Agricultural Growth Program-II

Participatory Agricultural Production Constraints Appraisal: Implication for Research and Development Interventions in Tigray, Ethiopia

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Participatory Agricultural Production Constraints Appraisal: Implication for Research and Development Interventions in Southern, North Western and Western Zones of Tigray

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1. Background

Tigray region is one of the nine regions of Ethiopia. It covers an approximate surface area of 54,572 km^2. According to the agro-climatic classification of the area, about 53% of the land is below 1500, 39% situated at 1500-2300 and 8% is over 2300 meters altitude (Beyene et al 2005). The Population and Housing Census of Ethiopia indicated that 80.5% of the total populations of the Tigray region are rural residents (CSA 2010). The rural population are dependent on agriculture and as agriculture is dominated by small holders, they need to be productive with the existing limited land resource but by employing agricultural inputs.

The Tigray region is generally regarded as an area with erratic and insufficient rainfall, poor soil quality; low availability of infrastructure like inputs and markets (Fetien et al 2009). Due to evident topographical variation in the region, Southern, North Western and Western Tigray have fertile soil and are conducive for agriculture though no remarkable production has yet been registered. Recently however, yield of crops has increased as a result of water and soil conservation activities, agro-forestry and crop diversification (Kumasi and Asenso-Okyere 2011). According to official statistics, over the past 15 years the average agricultural growth rate has been close to 7% per annum, indicating the potential for further increase of production to meet household demands, support agro-industry and for export.

The Government of Ethiopia and the development partners are collaborating and making concerted efforts on boosting agricultural development investment. The Agricultural Growth Program (AGP) is a clear example of this joint effort. AGP is an all-around investment program that supports agricultural productivity and commercialization of smallholders 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. To this endeavor in the Tigray region, three zones (Southern, North Western and Western) were the high agricultural potential areas identified for AGP intervention. The diversified agro-ecology of the selected zones is suitable to grow and produce varied types of crops, livestock and tree species. The selected zones cover much of the cultivated land (ZOARD, 2015) and the population of the Tigray region (CSA 2013). Before the planned AGP II intervention, a participatory problem

appraisal was conducted in the selected zones and districts to identify the major priority constraints that deserve immediate research and development attention.

2. Methodology

2.1. Description of the study areas

Southern zone is located between 12º15'and 13º41' north latitude and 38º59'and 39º54'east longitude with an altitudinal range of 1350-3925 meters altitude (EIAR and TARI, 2011) While, North western zone is located at 14^0 1' 13.4'' north latitude and 38^0 9' 50''east longitude, at an altitudinal range from 700-2200 meters and Western zone, 13°42′ to 14°28′ north latitude and 36°23′ to 37°31′ east longitude (Mekonnen et al 2011). A map depicting zones is also presented in Fig. 1. This diversified agro ecology makes suitable to grow varied types of crops, livestock and tree species. The study area covers an area of 9446, 18325.11 and 14335.31 km^2, in the southern, north western and western zone of Tigray, respectively (ZOARD 2015). According to CSA (2013) population projection, the total rural population projection of southern, north western and western zones for 2017 is estimated to be 975578, 696419 and 315366, respectively. The annual total rainfall of southern, north western and western is 600, 550-750 and 600 to 1800 mm and with mean annual temperature ranges of 25, 20-38 and 12-45^0C, respectively. Bimodal pattern of rainfall happens in the southern zone only. Dominant soil types in the southern zone are Vertisol, Fluvisols, Luvisols and Cambisols based on the FAO classification system.

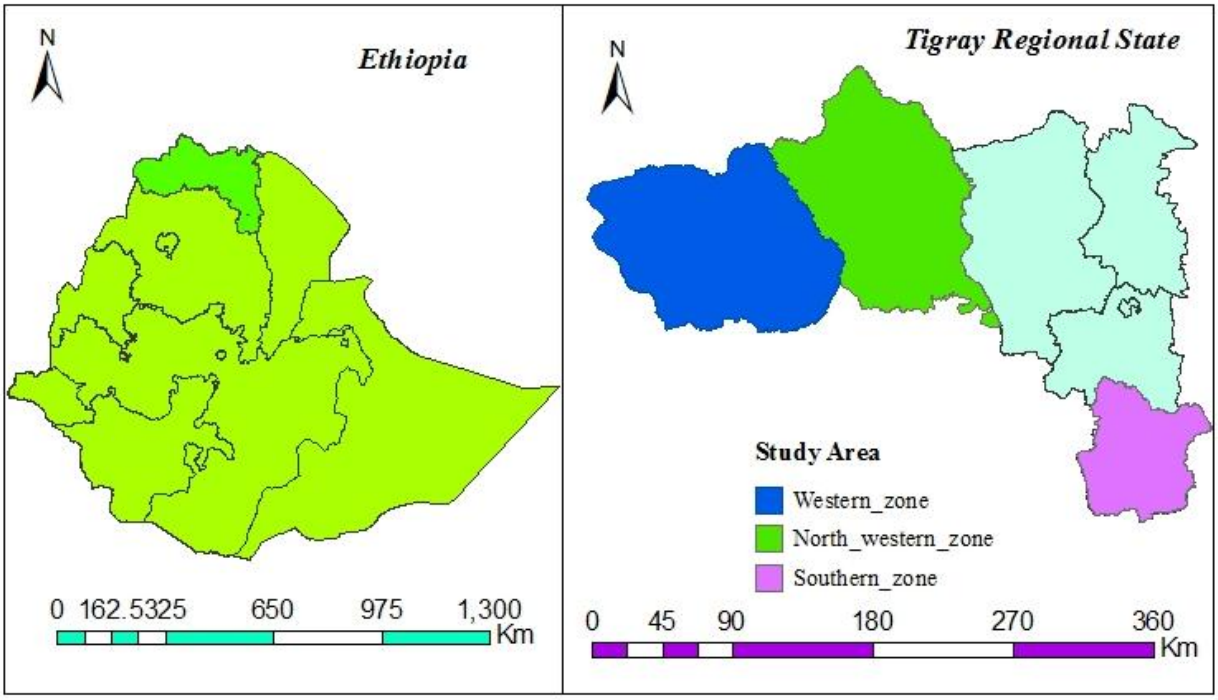

Figure 1.Location map of study zones

2.2. PRA groups selection procedure

In the selected three zones namely: Southern, North Western and Western and the thirteen AGP-II mandate woreda's, a stratified sampling was used to consider all the three agro ecologies of the study area and make the sample more representative. For this reason a total of forty four kebeles were randomly selected from the three districts; 7, 15 and 22 kebeles form high land, low land midland, respectively (Table 1). In selecting the sample respondents, consultation with office of agriculture and rural development (OoARD) of the districts and Peasant Associatios were made and voluntary farmers were invited for the group discussion. A group of female, youth, and mixed from all ages and sexes were created with a group size of 6 to 10 farmers.

Table 1. Sample respondent kebeles from each agro-ecology.

Zone	Districts	No of selected Kebeles in each Agro Ecology			Total No of kebeles	Total
		High land	Mid land	Low land		
Southern	Ofla	3			3	9
	Endamehoni	2			2	
	Raya Alamata			2	2	
	Raya Azebo			2	2	
North Western	Medebay-Zana		4	1	5	20
	Tahtay-Koraro		3		3	
	Asgede-Tsimbla		2	2	4	
	Tahtay-Adyabo			3	3	
	Laelay-Adyabo		2	1	3	
	Tselemti			2	2	
Western	Kafta-humera			5	5	15
	Tsegede	2	2	2	6	
	Welkait		2	2	4	
Total	13	7	15	22	44	44

2.3. Data collection

Quantitative data were collected using nine enumerator researchers. One-day training was given to the enumerators before deploying them for data collection. The training focused on overall introduction about the rapid assessment; they were also acquainted with the programs, objectives, tools and methodology of the assessment.

Two main data collection techniques were used. The primary data of existing farming systems and its problems were collected through focus group discussions; within each group in a participatory way. In addition, secondary data on demographic characteristics, agro-ecological distribution, land use, major crops, area coverage and productivity, livestock type and productivity, soil type and its distribution, major agro-forestry species, irrigation coverage and demographic nutritional statues at district level were collected from offices of agriculture and health of each district.

Participants were given a chance to list the problems, prioritize them and finally gave a way forward on the major intervention mechanisms to the priority problems through research and development. After finalizing the draft document, regarding the production constraints, relevant stakeholders were gathered for a validation work shop. In the workshop additional improvements

were suggested. Development and research tasks were also shared between the extension wing of BoARD and TARI.

3. Results and Discussion

3.1. Southern Zone Tigray

3.1.1. Area Descriptions

3.1.1.1. Geographical location and Agro-ecology

The geographical location, agro-ecology and area coverage of AGP II supported districts of Southern zone where the problems were appraised and presented in table 2.

Table 2. Geographical location and area coverage of the study districts in the southern zone.

District	Geographical location (degree)		Agro-ecology (ha)			Total (ha)
	Northing	Easting	Degua	Weynadegua	Kolla	
RayaAlamata	12.26 – 12.57	39.24 – 39.76	18829.7	0	56489	75318.7
RayaAzebo	12.32 – 12.95	39.56 – 39.98	0	150344	26532	176876
Ofla	12.64 – 12.87	39.27 – 39.61	56070	38715	38715	133500
Endamehn	12.36 -12.7	39.18 – 39.57	40057	18487.87	3081.3	61626.2

Source: OoARD of each district 2016

3.1.1.2. Climatic condition

The total annual rainfall for Raya-Alamata, Raya-Azebo, Ofla and Endomokni is 650, 600, 800 and 700 mm, respectively. Rainfall in all districts is bimodal. Raya-Azebo district has light rainfall during February to April and heavy rains between July to September. But heavy rain fall for Rya-Alamata occurs between June and September. The average temperature is 10, 21, 25 and 24 degree celcius for Endamokoni, ofla, Raya- Almata and Raya-Azebo, respectively. The minimum and maximum temperature and rainfall is summarized in table 3.

Table 3. Average temperature and rainfall of the study districts in the southern zone.

S.N	District	Average Temperature (^{o}c)		Total Annual rain fall (mm)	
		Min	Max	Min	Max
1	Raya-Almata	23	27	600	700
2	Raya-Azebo	22	26	400	800
3	Oflla	15	27	750	850
4	Endamohoni	8	12	600	800

Source: OoARD of respected districts 2016.

3.1.2. Farming system and natural resource management in southern Zone

The farming system in the districts is crop-dominant crop-livestock mixed production system though is still traditional. The undulating nature of the farmlands in the highland districts partly contributes the farming system to be traditional and not mechanized. The lowland areas of the zone are changing to commercialized farming especially with irrigation.

3.1.3. Socioeconomic set-ups

3.1.3.1. Land use and soil type

The land holding of individual farmers in the highlands of southern zone is smaller in size than the lowlanders. The most common source of labor in the study areas is family labor. During peak seasons of farming such as weeding and harvesting seasons, farmers use special labor arrangement mechanisms, such as "*Lifinti and Ofera*". Economically better households engage hired labor during peak seasons of farming. In line with double cropping practice using irrigation, there are lesser peak seasons of farming in the highlands than lowlands. The major land use types in the zone are cultivated, grazing land, forest area, and homestead and water bodies. The dominant soil classes are clay, silt, clay loam and sand. The detail area coverage and proportion of land use for each district are summarized in table 4.

Table 4. Area coverage of land use types in the districts.

Land use type	Raya-Alamata		Raya-Azebo		Endamehoni		Ofla	
	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
Cultivated land	36228	48.10	474889	54.8	17434	28.3	21707	16.26
Forest	16909	22.45	295589	34.1	16911	27.4	25435	19.05
Grazing land	9243	12.27	54994	6.3	14464	23.5	29856	22.36
Homestead	8029	10.66	41537	4.8	12002	19.5	-	-
Others	4911	6.52	-		817	1.3	44635	33.43

Source: OoARD of respective districts 2016

3.1.3.2. Livelihood strategies of households

Crop/livestock farming is the primary source of livelihood for the southern zone. Some farmers are also engaged in off-farm and non-farm activities though it is not considered as dependable means of livelihood. There are also households who receive remittances from relatives. According to this PRA exercise, mixed crop-livestock production is the major agricultural

economic activity. In addition, there are people who engaged in petty trading and livestock trading (sheep, goat, camel, oxen). Usually, they purchase the animals from the neighboring regions like Afar and Amhara and sell them in the surrounding district and local markets. Sometimes they also take the animals to markets in Mekelle.

3.1.3.3. Agricultural knowledge and iinformation ssystem and technology factors

The technology transfer methodology is mainly top-down approach. The main source of technology is office of agriculture and rural development in rain fed crop production and livestock technologies. The main channel used for technology transfer is mostly conventional i.e. every information related to new technology is transferred to development agents and local administrators. The local administrators and development agents of the respective district are expected to transmit it to the local communities. Knowledge of farmers in agricultural activities is gained through formal (training) and informal ways. The formal ways are through trainings and experience sharing, field visits and exposures given by office of agriculture and different stockholders (AARC, MAMREREC, MSRC, MARC, REST, CASCAAP, MU etc). The informal ways are through farmer to farmer knowledge sharing and investors to farmer experience sharing.

Different trainings are also offered in the respective districts focusing on crop management (row planting, fertilizer application, weed and pest control), beekeeping, and human nutrition etc. But, mostly the trainings are theoretical. Training on marketing, farm record keeping, and post-harvest losses management are not given so far in the zone. In addition there some institutional problems and are listed and explained below.

- Organized center for market information is not available, but some of the farmers receive market information through mobile and asking relatives even if the decision is made by the consumers.
- Cooperatives that support production and marketing are available in the districts although these cooperatives are mainly focusing on supply of fertilizer even though they are expected to consider other issues such as purchasing and selling of farm products.
- Institutions that supply fertilizer, improved seed, improved implement and chemicals are available in the districts. But, they cannot fulfill the demand of the farmers particularly on

improved seed and agro-chemicals. The institutions in the districts didn't focus on improved implements.

- Most of the kebeles are connected (transport) to the center of the districts, but currently all-weather roads in the district are not fully available.

3.1.3.4. Gender roles and decision making

Understanding the gender context of agriculture will be central to successful intervention. Women play key roles in the workload and sharing of resource and benefits of production in agriculture. Women participate in every aspect of crops production and other family activities starting from land preparation, seedling raising, transplanting, fruit propagation, weeding, harvesting, seed preparation and marketing etc. They are a major part of labor force in the field and housekeeping activities. In addition to that most of the responsibilities in social affairs are managed by women.

In a given household, live animals are equally owned by the husband and housewife. Both male and female household members almost equally participate in feeding, watering, milking and health management practices. In addition, livestock and their product market decision is decided by both female and male household members except poultry, poultry products, milk and milk products that managed exclusively by female household members.

Based on the focus group discussion, it was found out that men and women share different roles and responsibilities in farming, domestic and other activities. Women are mainly responsible in crop production for weeding, transporting harvests, heaping of harvested crops and only rarely do they plow. Similarly in livestock production, milking of cows, cleaning animal barn, milk processing and preparation of dung cakes for fuel energy source are common responsibilities of women in livestock production. However, Men are mainly responsible for land preparation, planting and harvesting of crops. Feeding and health care of animals are responsibilities of both men and women.

3.1.3.5. Nutritional status of households

Certain groups are more vulnerable due to continuous drought and lack of skill and knowledge in food preparation and feeding mechanisms. The major meal types consumed include *enjera* (composition of sorghum + tef), *Kicha* (flat bread) from wheat and sorghum; and stew (*shiro*,

potato, milk, *Keikei* and tomato). *Shiro* is a homogeneous stew whose primary ingredient is powdered chickpeas or broad bean meal or field pea. Farmers brought most of their food source from own farm production but some bought from market and others get gift especially those used for *shiro* (faba bean, chick pea and field pea).

Age and status based diet preparation is poorly practiced. Infants (age less than two years), age between 3-5 years are nutritionally marginalized. Lactating and pregnant mothers and productive age group ranging from 16-65 years old does not receive balanced diet. But, there is a tradition that mothers during weeks of parturition get some additional diets like *Genfo*, *besso*, honey and butter. Mostly the community does not practice balanced diet based on body requirement or age. The community receives nutrition trainings and demonstrations by health office. Demonstration on food preparation from green gram, cactus and moringa are held though are not practiced by the farmers.

Shelf life for the major meal types is not a common problem but sometimes *enjera* and *kiekie* are easily perishable. But, usually food is prepared to serve it immediately while some might put it in cold place and hygienic handling are the copping mechanism practiced by the local community. Most of the time, even though farmers have access to milk and egg, they don't commonly use them in their daily diet.

3.1.3.6. Food preparation process

Steps of food preparation from sorghum (Fig. 2) and legumes (Fig. 3) practiced are summarized. The food preparation process from sorghum shows there is no application of dehulling process on colored sorghum varieties.

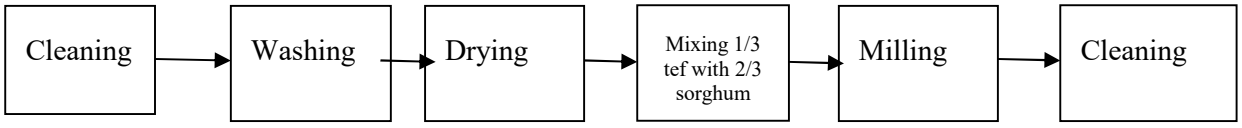

Figure 2. Steps of injera preparation from sorghum

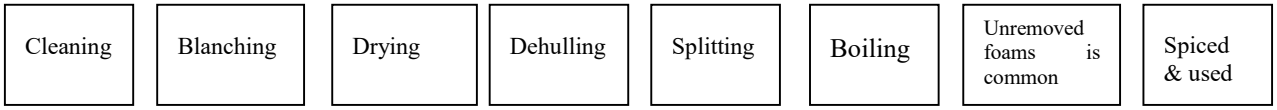

Figure 3. Steps of stew preparation from legumes.

Legumes require special pre-conditioning and processing before consumption not only when they are fed to the young and elderly but also for those that need special care and also for all the community members.

The main prioritized nutritional security constraints of the districts are

- Lack of organized institutions working on nutrition
- Skill and knowledge gap in blended food preparation
- Poor attention to malnutrition prevention methods
- Unknown nutrient density of the existing commodities of farmers
- Theory-based nutritional trainings and demonstrations.

Prioritized and screened nutrition security problems

The main important causes of nutrition insecurity are

- Unbalanced feeding habit in the community
- Skill and knowledge gap on balanced nutrition
- Poor attention to malnutrition prevention methods
- Nutritional demonstrations and trainings not practical oriented
- Lack of organized institutions working on nutrition improvement

Research recommendation on food science and nutrition

Food science and nutrition research proposals

- Currently animal protein is becoming expensive to access it. So to get alternative and cheap protein source from plants, research intervention to improve food processing skills of farmers is needed.
- Preventing malnutrition and preparation of complementary foods at home level
- Value adding and incorporating vegetable into the daily meal.
- Awareness creation about the anti-nutritional factors in undehulled colored sorghum recipes.
- Managing post-harvest loss of cereals and vegetable crops

- Identifying existing local and improved crop varieties based on their nutrient content for better formulation of weaning foods (supported with food science and processing technology).

3.1.3.7. Input and credit environment

Farmers of the study area get credit mainly from Dedebit Credit and Savings Institution (DSCI) in two forms. The first is credit which they call *medebegna* (regular) and is offered on a group-basis where at least 3 people form a group and everyone in the group is responsible for the timely repayment of the total sum borrowed by all three persons. If one person in the group fails to pay back the amount, the other two will be liable for the repayment of that amount. Once a group is formed and the credit requested, loan is granted. The second form of credit is offered on an individual basis in the form of a package. The amount of money borrowed with this method is relatively higher and most farmers prefer this kind of credit granted from DCSI. The only drawback is that it takes too long time to process and it has higher interest rate (18%). Farmers use this loan mainly for fattening of cattle and rearing of dairy cows. The maximum amount of loan that individual farmers can receive from DECSI is up to 8,000 Ethiopian birr.

There are also established savings and credit cooperatives intended to encourage the community to save money and to provide credit to the members at a lower interest rate. The amount of credit that can be provided to members is up to three folds of the amount saved by the individual. Multipurpose cooperatives are another organization at *Kebele* level which are playing important roles in supplying different agricultural inputs (seed, fertilizer and chemicals) as well as consumable items to the community. FGD participants reported that multipurpose cooperative purchase most of the items from the district towns and as a result there is no much price difference with the same items supplied by other private traders.

3.1.3.8. Rural energy sources of the study zone

The main energy sources existing for the farmers day to day activities like cooking, baking and boiling are firewood, cow dung and crop residues. But for lighting purpose farmers use movable solar energy sources and electricity. However, farmers are not satisfied with the traditional source of energy and alternate source of energy (solar and electricity). The reason for dissatisfaction with solar energy is its inability for cooking and baking activities and the

associated high cost. Moreover, electricity supply is limited only to very few farmers near the towns. The main constraints related to household energy demanding activities are shortage of firewood and limited supply of alternative sources of energy. For agricultural practices like water uplifting and drying most farmers don't use any alternative source of energy. Some farmers however use diesel motor pump for water uplifting.

3.1.3.9. Climate Change

Farmers have observed the climate changing from year to year such as increase in temperature and erratic rainfall in amount and distribution. Climate change is also making their environment difficult to travel and work on their farm. Sudden droughts and rainfall harm animals, crops and humans. According to FGD participants, people have got climate information from DAs and media and the farmers themselves have also sensed the difference in climate from their experience. In response to the climate change, farmers of the study area use different copping mechanism such as use of early maturing crop varieties, water harvesting practices, giving emphasis to irrigated agriculture, off-farm activities, food aid, selling of livestock, borrowing and sharing of commodities, efficient utilization of food and feed and collecting crop residues (sorghum stalk) which were not previously practiced.

3.1.3.10. Market and infrastructure

The major markets for the study zone are local markets at kebele and district level. Most of the grain exchange and purchase of consumable goods are done in these markets. Farmers also travel to the district market to sell surplus agricultural products such as onion and tomato. According to the participants, there is very little price difference between the local markets and the district markets, especially for the items they purchase. They however, get better prices at the district markets for onion and tomato.

3.1.3.11. Agricultural machineries

According to the group discussants there are no any improved agricultural machineries for rain fed crop production introduced into their area. But few tractors with private investors in the irrigated lands and tie-ridging implements are introduced even though no demonstrations are held. Few wheat threshers are also introduced by the bokra union in the highland districts. There is also high post-harvest loss of crops due to the unavailability of the required postharvest

technology. Farmers prioritize farm operations activities as plowing, threshing, harvesting, and transporting based on labor requirement, cost and time consumption.

3.1.3.12. Constraints in technology transfer

- Poor linkage between research and extension
- Lack of working modality for the transfer of technologies
- Trainings and orientations are mostly limited to farmers participating in different administration positions, not consider gender and similar farmers are trained repeatedly.
- Some technologies are not well demonstrated practically at farmers field level (eg: synchronization)
- Trainings in marketing and cooperatives in agricultural production is limited.

3.1.3.13. Knowledge management constraints

The technology transfer methodology is mainly top-down approach. The main source of technology is office of agriculture and rural development in rain-fed crop production and livestock technologies. However, local market is also main source of technologies for irrigated agriculture. The main channel used for technology transfer is mostly conventional. The information related to new technology is transferred to development agents and local administrators through trainings and verbal orientations. The local administrators and development agents of the kebelles are expected to transmit the information related to the new technology to the whole community. However, some stakeholders like agricultural research centers and universities demonstrate technologies in the form of clusters directly to few farmers.

The following are the main constraints of technology transfer

- Few farmers trained repeatedly
- Inappropriate selection of trainers
- Low attention to gender issue
- Training in marketing, cooperatives in agricultural production and products to local farmers is not common.

3.1.3.14. Socioeconomic and policy considerations

- Livestock development policies and programs should be performed effectively at all stages of production level.

- Improved seed and other input provider institutions should be established
- Capacity development systems should be outlined and performed at different levels starting from the farmer.
- Experience sharing among farmers need to be strengthened for easy technology adoption and knowledge transfer.
- Focus should be given to nutrition security
- Sectors and stakeholders should be focused on transforming agriculture.
- Chemical fertilizer is very expensive and needs the establishment of fertilizer formulation factories and provides the fertilizer at reasonable price.
- Credit institutions should provide services to farmers at affordable interest rates..
- FTCs strengthened to become real demonstration and training centers.
- Sectors should focus on problems of malnutrition

3.1.4. Crop production in Southern Zone

The major crop commodities grown in the highland districts of the southern zone (Ofla and Endamohoni) include wheat, barley and faba bean. In 2016 cropping season 5964, 4292, and 1740 ha were covered by both local and improved wheat, barley and faba bean varieties, respectively in the Endamohoni district (Table 5). These crops, in the same order, as above, have area coverage of about 7481, 3915 and 1266 ha in Ofla district (Table 6).

Table 5. Area Coverage of major crops of Ofla district, 2016 cropping season

Crop type	Area (ha)			Productivity (qt/ha)	
	Local	Improved	Total	local	Improved
Wheat	3740.5	3740.5	7481	19	27.5
Barley	3905.5	10	3915.5	12	31
Faba bean	1041.75	225	1266.75	19	24
Field pea	605.5	235	840.5	15	17.5
Maize	1393	-	1393	26	-
Sorghum	1270	-	1270	10	-
Zengeda	554	-	554	30	-
Teff	796	65	861	7.5	9
Dagusha	475	-	475	6	12
Check pea	2511	-	2511	-	-

Source: Ofla OoARD 2016

Besides Tef, field pea, Sorghum, maize, check pea, lentil are also the most commonly grown crops (Table 5). Sorghum, wheat and teff are commonly grown crops in Raya-Alamata and all crops cover an area 3244.5 ha in 2016 cropping season. Sorghum, wheat and maize, tef, are the major crops grown in the in Raya-Alamata district. In 2016 cropping season 1129.5, 1800 and 315 ha of land was covered by sorghum, wheat and teff, respectively. Sorghum, teff and maize are dominant crop types grown in Raya-Azebo district. Beside mixed crop-livestock, farming is the dominant farming system of the district.

Table 6. Area coverage of major crops grown at Endamohoni district, 2016 cropping season.

Crop	Area (ha)		Total	Proportion (%)		Productivity (qt/ha)	
	Local	Improved		Local	Improved	local	Improved
Wheat	3204.25	760	5964.25	87.26	12.74	-	30
Barley	4289	3	4292	99.93	0.07	-	32
Faba bean	1731.38	9.375	1740.75	99.46	0.54	-	8
Tef	1731.5	-	1731.5	100	0	20	-
Field pea	1288.12	-	1288.12	100	0	25	-
Sorghum	232	-	232	100	0	20	-
Maize	231	-	231	100	0	-	-
Zengeda	186	-	186	100	0	-	-
Lentil	741	-	741	100	0	-	-
Check pea	63.5	-	63.5	100	0	-	-

Source: Endamehoni OoARD 2016

3.1.4.1. Rain-fed crop production

Sorghum, tef and maize are the major lowland crops whereas wheat, barley, faba bean, Teff, field pea and lentil are the major highland crops grown under the main rain season. In addition wheat, chick pea and '*Dekeko'* are also important crops next to the above three for the lowland part of the study zone. The average productivity and farmers' perception on major and secondary crops of each study districts are listed in Appendix table 2. Farmers estimate the productivity of crops by considering the soil fertility status and rainfall variability.

3.1.4.2. Rain fed Soil fertility management

The common practices of soil fertility management in lowland areas of the zone (Raya-alamata and Raya-Azebo) include application of chemical fertilizer, selecting appropriate time of plowing, preparation of soil bund/gedeba/for moisture conservation, early plowing after harvest, planting agro-forestry near homesteads for fencing and shading and flood water harvesting to their farming land (Spate irrigation) during rainy season and manuring. Similarly inorganic fertilizer use, crop rotation, manuring and frequent plowing are the common activities of soil fertility managements that most farmers practice in Endamohoni and Ofla. However, in the zone soil test based blended fertilizer use, compost and vermin compost use, crop cover, inter-cropping and fallowing are not common to most of the high land farmers. Besides, farmers at the lowland areas do not practice crop rotation as soil fertility management practice.

3.1.4.3. Main challenges and constraints in rain-fed crop production

Lack of improved varieties and seeds is the main one but some improved varieties are also poorly adaptable while still some not accepted by farmers. The study area is also threatened by diseases (rust, chocolate spot), insect pests (aphids) and rodents. Abiotic stresses such as freezing and chilling are also common. Disease and pest problem is aggravated due to shortage of effective pesticides, poor quarantine and agronomic management. Erratic rainfall also limits production and productivity the rain-fed agriculture. Poor linkage with partners in extension system also delays supply of inputs and affects quality of improved seeds.

Agricultural machineries like sorghum thresher, dehuler, tef thresher, row planter, and harvester are also short in the zone. These problems are either due to lack of suppliers, financial shortage, and skill and knowledge gap of users. Lack of farm machineries and poor awareness of farmers about them leads to huge yield loss during threshing and harvesting. The importance of harvesters and threshers become relevant especially during sudden rains.

3.1.4.4. Prioritized and screened rain-fed crop production problems

The major crop production challenges and constraints in the southern zone in order of their importance are

- Moisture stress and sometimes freezing and chilling

- Disease and pest (Rust, chocolate spot, shoot fly, stock borer, , armyworm, grasshopper, Aphids, rodents)
- Shortage, and delay of inputs (Fertilizer pesticides and sprayers) and some not affordable to farmers.
- limited access to improved seed and variety
- Poor knowhow on improved farm implements
- Soil fertility decline
- Water logging and increased salinity
- Lack of accesses to credit services for purchasing fertilizer
- Invasive weeds and free grazing
- Flooding of farm lands
- Poor market access, chain, linkage, market price fluctuation and transportation facilities
- Poor quality seeds
- Loss of yield during postharvest
- labor shortage for weed management
- Restrictions on pesticide use due to bee production

3.1.4.5. Crop production recommendations

Crop research directions:

- Introduce/adopt moisture stress tolerant technologies (varieties, practices …)
- Identifying insect pest and disease control methods for major ones.
- Investigate management of invasive weeds
- Improve accesses to early generation seeds of target crops.
- Introducing, adopting and demonstrating appropriate farm implements for major crops (row planting, weeding, harvesting, threshing and dehuling).
- Identification and verification of soil fertility enhancing technologies.
- Improving existing food types and introducing nutrition rich food crops.

- Introduce soil-test based fertilizer application
- Introduce integrated soil fertility management methods
- Capacity building in post-harvest handling and value addition to major crops and stabilize markets across seasons.
- Introduction and adaptation of insect pest and disease tolerant varieties
- Strengthen the breeding strategy of crops for better accessibility.(barley, maize and sorghum)

Crop developmental directions

- Improving the supply of pesticide at community level with manageable packing size and affordable for individual farmers.
- Capacity building on disease and pest management skills.
- Establishing and strengthen seed producer farmer cooperatives.
- Filling gap in skill on agricultural farm implement operation and maintenance.
- Contribute to sustainable supply of improved farm implements
- Capacity building in soil fertility management concepts and practices.
- Creating and empowering local credit and saving institutions to support crop production.
- Capacity building on seasonal crop productions to control market fluctuation.
- Adapting flood damage controlling mechanisms.
- Capacity building on complementary food preparation.
- Supply of blended fertilizer, bio fertilizer, vermin compost and gypsum
- Giving attention and control to the invasive weed specially Parthenium
- Strengthen research and extension system
- Intensive training of farmers.

- Capacity building on integrated soil and water conservation practices.

3.1.4.6. Irrigated agriculture crop production system

The major source of irrigation water in southern Zone is canal diversion from groundwater and spring water. In addition hand-dug wells are also common in the highland areas but spate irrigation is also common in rain-fed crop production in the lowland areas where water is applied using gravity furrow irrigation. Farmers also use electrical motor pump and diesel motor for uplifting groundwater and deep wells, respectively. Electrical pump users are farmers under the modern irrigation scheme and the other (diversion and diesel motor pump) users are those under traditional irrigation schemes.

Irrigation interval varies from two to four weeks depending on the crop type and size of irrigated land. The amount and time of water application is not based on the crop water requirement criteria rather it is simply decided by Water User Associations (WUA) leaders traditionally based on crop type and area coverage. From the group discussion, farmers have low irrigation water use efficiency. To achieve economy in the use of irrigation water, farmers need to be told that only certain fixed amount of water gives best yield. Majority of women-headed household do not participate in irrigation due to shortage of labor. However, few women- headed households get a privilege to irrigate their farmland at day time.

Major crops grown in the southern zone with irrigation are maize (melkasa-2 and melkasa-4), onion, tomato, cabbage, pepper, shallot, papaya, chickpea, field pea, potato, *Sasula,* garlic, carrot, beet root, potato, lettuce and hop. Even though their coverage is low, fruits such as avocado, guava and mango are also grown in the area. *Feteno, emawayish and Keysenadir* are local maize cultivars commonly grown in irrigation schemes of the Zone.

The average productivity of local maize varieties in lowlands is 4.0 t per ha compared to 5.8 t per ha with an improved. The perception of farmers on productivity of the maize varieties, improved or local is low while their perception on productivity of onion varieties (Adama and Bombey red), with an average productivity of 20.0 t per ha, is high though the varieties differ in bulb color and market value.

The pepper cultivars grown are mostly local and had an average productivity of 12.0 t per ha yet farmers perceive the productivity as medium. The average productivity of improved cabbage is 24.0 t/ha and is perceived as medium productivity by farmers. Productivity of improved tomato was 30.5 t/ha and its yield was perceived as high. Farmers grow improved varieties of papaya and lettuce but only local cultivars of hop. Average productivity of hop, papaya and lettuce is 32.0, 4.0, 2.0 t/ ha, respectively and their perception of productivity is medium, high and medium. The average productivity and perception of farmers on irrigated crops in the highland districts is summarized in the Appendix table 3.

3.1.4.7. Challenges and constraints of Irrigated crops

- Shortage of irrigation water and poor canal efficiency
- Shortage of improved varieties both in quantity and quality
- Pests and diseases
- Knowledge and skill gap on crop pest management
- High salinity level at irrigated fields
- Lack of access to effective pesticides
- Lack of small-pack pesticide for small growers.
- Lack of improved tools for post-harvest processing and handling (harvester and hop chopper and dryer).
- Lack of irrigation implements and accessories and low pumping potential of some electrical motor pumps
- Storage problem (cold room) in vegetable crops
- Poor know how on improved farm machineries and implements
- Poor market linkage (low price of produce during peak harvest).
- Lack of infrastructure (road)
- No value addition during market failure; in tomato, carrot and potato
- Shortage of irrigable land
- Informal market information and very high price fluctuation
- Frost

3.1.4.8. Prioritized and screened irrigated crop production constraints

The major irrigated crop production challenges and constraints in relation to input, production, processing and marketing in order of their importance are:

- Crop pests and disease
- Shortage of supply of improved seeds
- Shortage of irrigation water and poor diversion canal management.
- Lack of small-pack pesticides for small scale farmers.
- Poor market linkage and low price
- Lack of improved tools; potato harvester, tomato seed extractor and drier
- Lack of post-harvest handling, packaging and storing technologies for vegetable and fruit
- No value addition especially during market failure for in tomato, carrot and potato
- Lack of infrastructure (road)

3.1.4.9. Recommendations for irrigated agriculture

Research directions for irrigated agriculture

- Knowledge gap in production calendar for maximum profit.
- Introduction, evaluation and demonstration of disease and pest resistant improved varieties and agronomic practices.
- Introduction and demonstration of seed production systems for major crops in the irrigation schemes.
- Demonstration of seed multiplication for onion and tomato
- Verifying ATA soil map at farmers' field and introducing soil test based fertilizer application.
- Introducing integrated soil fertility management
- Introducing and adopting irrigation implements and accessories (for planting, weeding, harvesting, irrigation equipment's and techniques).
- Determination of crop water requirement of major crops and improving irrigation water application options. Evaluation and pre-scaling up of different deficit irrigation options like surge irrigation, alternate furrow irrigation, irrigation at critical stages, irrigation based on soil water depletion, conjunctive use of irrigation

and low pressure drip irrigation system could help in minimizing the shortage of irrigation water. Moreover, awareness creation, training and experience sharing for farmers and development agents in agricultural water management can also contribute for improvement of irrigation water management.

- Determination and verification of effective, efficient and optimum agricultural water management technologies for small scale farmers. This may be related to crop water requirements, irrigation scheduling, and integration of irrigation with agronomic practices, performance evaluation of the existing irrigation schemes, existing irrigation canal management and different water application techniques.
- Testing, verification and Pre-scaling up of low-cost and low-pressure micro-irrigation system (ex. family drip irrigation system) and deficit irrigation options.
- Appraisal and promotion of indigenous knowledge and traditional practices of on–farm irrigation water management practices
- Appraise control and prevention measures for both existing and newly established irrigation schemes. This mainly focus on the awareness creation to the community and other stake holders is to prevent and control newly developed irrigated land and create early warning awareness and training on the consequences of irrigated agriculture (salinity development and water logging and related problems).
- Introducing and adopting transportation in irrigation schemes
- Capacity building in post-harvest handling and value addition
- Demonstrating cropping calendar and value addition technologies for the horticultural technologies.
- Demonstration of low cost storage options

Irrigated agriculture development directions:

- Improving access to chemicals and supply of small-pack pesticides for small scale farmers.
- Establish and strengthen seed system cooperatives at irrigation schemes
- Strengthening the existing research and extension linkage and the need of strong extension services for irrigation water management.
- Modernized irrigation systems (sprinkler and drip irrigation system)

- Capacity building on seasonal crop production to control market fluctuation, irrigation crop disease and insect pest management.
- using improved farm machineries
- Expansion of the evaluated and demonstrated improved technologies related to disease and pest management
- Improving market infrastructure and empowering of farmers' cooperatives
- Constructing of common mechanized storage system
- Creation of market linkage and establishment of farmers cooperatives for irrigation agriculture

3.1.5. Livestock Production

3.1.5.1. Livestock types

Farmers during the FGD reported that animals such as cattle, shoats, poultry and equines are the major livestock resources reared in the southern zone. Cattle breed is mainly local Arado and harmo raya breeds. There are also some newly introduced begait, borena and HF crossbreeds. Sheep breeds are mainly local Ille breeds and there are also some newly introduced begait breeds as well. Goats are all local breeds. In addition to the availability of local poultry breeds, improved breeds like bovines brown, red Iceland (IRR) and kockeke are the commonly introduced. Majority of farmers are interested with improved breeds but they don't often rear improved breeds due to shortage of begait cattle and sheep breeds, high price and high feed consumption (HF), less access to improved shoat breeds and feed shortage. Due to the above mentioned reasons, still local breeds are larger in population than improved ones.

3.1.5.2. Livestock production

The main livestock types dominantly rearing in Raya-Alamata, Raya-Azebo, ofla and Endamohini are cattle, small ruminants, poultry and equines. Their population, production and productivity for each district are summarized in appendix table 1. The main livestock production constraints for the lowland districts of Raya-Azebo and Raya-Alamata)are shortage of feed, livestock diseases, poor quality of livestock breed and external parasites. The main livestock production constraints for Endamehoni district are feed shortage, shortage of grazing land,

disease, poor livestock breed and poor management. Similarly shortage of feed, livestock disease and poor performing animal breeds are the main constraints for ofla district

3.1.5.3. Livestock productivity

According to focused group discussion, the average milk productivity of local and improved cattle is 2.5 and 7.5 lt/day/cow, while, the average butter production is 1.25 and 0.75 kg/week/head, respectively. Farmers perceive that local breeds produce more butter than improved. The average egg production of chicken is 144 and 300 eggs/year/head for local and improved, respectively. Farmers have high discernment for egg productivity of improved poultry breed and low for egg productivity of local poultry breeds.

3.1.5.4. Livestock rearing purpose, breeding and feeding ttechniques

Cattle are reared primarily for farming and as source of income. In addition, small ruminants are reared for cash income and home meat consumption mainly during public holidays. Moreover, poultry are reared mainly for cash income as well as their products and rarely used for home consumption. Some farmers exercise cattle breeding by selecting local bulls. Majority however exercise uncontrolled breeding. Besides, small ruminants and chickens breeding is uncontrolled. Artificial Insemination (AI) service is poorly practiced in the districts. Cattle and small ruminants are fed through free grazing though in the rainy season cattle are fed cut weeds along the roadside. Small ruminants are browsing free throughout the year while chickens are self-scavenging.

3.1.5.5. Livestock production cconstraints and challenges in southern zone

The major livestock production challenges and constraints related to input, production, processing and market are

- Shortage of good quality feed and water.
- Livestock diseases (shoat pox, NCD, external parasite, CBPP, *taetaeta,* foot and mouth, anthrax, snail hosting, bovine and ovine pasteurolosis and black leg)
- Shortage of grazing land
- Less productive livestock

- Poor supply of improved breeds (sheep and goat)
- Poor animal health delivery system (vaccine, drugs and veterinary equipment's)
- Lack of improved dairy processing technology
- Limited dissemination of improved poultry breeds.
- Poor market value chain on livestock and livestock products.
- Poor skill and knowledge on livestock management.
- Housing and housing management (poultry).
- Market price seasonal fluctuation.
- Water logged Pasture land (Hashenge kebele)

Generally, there are no modern animal farm technologies introduced into the area. Farmers prioritized farm operations based on time consumed, labor and cost required. Feed preparation, housing and healthcare are therefore listed in their order of importance. Farmers in the focused group discussion mentioned introduction of improved forage species like cowpea, elephant grass, alfalfa, *Sesbania* and *Lucinia* by the offices of agriculture and rural development of the districts. But its coverage is limited to few farmers and not well identified on variety level. Besides, there was no modern livestock feed utilization and management exercises.

3.1.5.6. *Prioritized and screened livestock production problems*

The major livestock production problems related to input, production, processing and market are:

- Shortage of feed and water, poor quality feed and high price of concentrated animal feeds
- Livestock diseases
- Less productive of livestock breeds and inbreeding problem
- Lack of improved dairy processing technology
- Poor market and value chain, price fluctuation and processing on livestock and livestock product.
- Poor animal health delivery system
- Skill and knowledge on livestock management

- Lack of managed grazing lands

Livestock research directions:

- Selection of best indigenous animals through community based selection and breeding
- Reduce herd size and replace existing breeds by few productive local and crossbreed cows (cattle:- HF, sheep:- Dorper and Bonga, Begait)
- Use artificial insemination to gradually upgrade productivity of local breeds
- Characterizations of indigenous cattle, sheep and goat on- farm and identify breeds for specific purposes (milk, meat, power, export, local market).
- Demonstration of market oriented on-farm fattening on cattle (bull calves) and small ruminants.
- Identify appropriate age and weight for fattening beef cattle and small ruminants.
- Development of forage varieties and multi-purpose trees: introduction, adaptation and demonstration.
- Intercrop forage species with cereals
- Pre-scaling up of well adapted and drought tolerant feed technologies.
- Community based forage seed production and maintenance.
- Introduction and adaptation of irrigated forage varieties.
- Improve livestock husbandry.
- Introduction and demonstration of livestock feed quality improvement technologies.
- Collect crop residue and hay and bail to preserve it for use in feed shortage seasons.
- Plant fodder trees and shrubs near farm boundaries and irrigated fields
- Improve quality of available feed resources (by physically chopping, grinding; chemical (urea treatment, UCB and UMB) and biological (microbes)
- Improving grazing land productivity through rehabilitation and restoration

- Improve the quality of the pasture land with recommended better fodder species (i.e. Alfalfa and Vetch) and other improved technologies like Urea application.
- Identification, evaluation and prioritization of economic important disease and recommend/suggest possible interventions

Livestock developmental directions:

- Encouraging area enclosure
- Raising level of awareness of farmers on utilization & handling of crop residues and development intervention.
- Skill and knowledge gap filling in livestock management
- Develop water points of livestock.
- Timely vaccination and treatment of livestock
- Introducing zero grazing by supporting with improved livestock technologies
- Collect, bail and maintain crop residue and hay for use in feed shortage seasons.
- Organize farming community-based forage seed production system as income generation
- Organize farmers (youth) cooperatives that keep and sell livestock and livestock products.

3.1.6. Natural resource management

3.1.6.1. Communal resources management

In group discussion, different physical, biological soil and water conservation practices like terracing, planting trees and in-situ soil and water conservation are commonly practiced. The physical structures are also combined with biological conservation methods like planting Aloes. The constraints related to natural resource management are as follows: soil and water conservation activities in the highlands are more focused on communal than farmlands, lack of experience on utilizing lands restored through natural resource management and shortage of gabion to treat gulley on farm lands. Agro-forestry is not commonly practiced in the zone except planting some trees near homesteads for fencing and shade purpose. Because, farmers think trees on farms can have shading effect onto their crops. The contribution of trees for soil fertility

improvement and increasing crop productivity is not well understood by the farmers. Spate irrigation is also commonly practiced to satisfy water requirement of their crops.

Efficient soil and water conservation needs development of holistic watershed based natural resource management technologies following participatory approaches to strengthen collaboration among stakeholders. Main constraints to performing soil and water conservation practices in participatory way in the southern zone are shortage of labor, unavailability of soil and water conservation materials (gabion) and technical skill limitations. The poor soil and water conservation practices lead to run-off from upper catchment areas that in turn cause erosion and sedimentation on farm lands. There is also of loss of cultivated and grazing lands due to flooding which is accelerated by destruction of constructed terraces by freely roaming animals. Recently, occurrence of soil salinity and water logging has become a challenge at Tumuga kebele.

3.1.6.2. Soil characteristics and management

The major soil types of the area identified from the group discussion are clay, loam, sandy, gravel and saline. However, a small area has marginal soils, locally called *Chincha meret*. Farmers classify soils based on color, depth and relative position of the land in the watershed. The fertility of the land has decreased due to continuous mono-cropping in the lowlands and lack of fertilization and management of the land in highlands. Farmers use chemical fertilizer, farmyard manure and compost for soil fertility improvement. The use of mineral fertilizer varies according to soil and crop type. DAP and Urea, for example, are applied for wheat and barley on clay soil.

NRM constraints and challenges

- Agro-forestry is not commonly practiced in the zone
- Soil salinity and water logging is becoming a challenge on cultivated lands.
- Soil fertility decline due to continuous mono-cropping (sorghum) with no fertilization.
- Labor shortage for soil and water conservation on cultivated lands,
- Limited availability of soil and water conservation materials (gabion) and technical skill gaps.
- No experience on benefits of natural resource management

- Run-off from upper catchment areas causes erosion and sedimentation on farm lands in the highlands.

Natural resource and crop production constraint interrelationships

The major constraints and knowledge gap on soil and water conservation practices in the zone and identified from the group discussion include labor intensive nature of the soil and water conservation, unavailability of modern spate irrigation techniques and physical conservation structures not supported with tree planting. Free grazing also affects area enclosures and lead to poor survival of tree seedlings.

There is no any introduced agro-forestry species in farmland to help natural resource management. Recently**, s**alinity problem was observed in some localities and farmers have no idea of any mitigation measures.

3.1.6.3. Prioritized and screened natural resources management problems

Problems associated with natural resources management in the districts are:

- Land degradation
- Flooding hazards
- Recurrent drought
- Indigenous tree species extinction
- Poor tree seedlings survival
- Knowledge and technical gap on soil and water conservation measures
- Shortage of construction materials for conservation of spate irrigation and other physical conservation measures
- Free grazing

Prioritized soil problems

Problems associated with soil in the districts are

- Top soil removal
- Soil nutrient depletion
- No soil test based fertilizer application (Blanket fertilizer recommendation)

- high cost of chemical fertilizers and no supply of bio-fertilizer
- Poor management of organic fertilizer (manure, compost, mulch, crop residue)
- Poor agronomic practices (shifting cultivation, intercropping)
- Shortage of composting materials and technical gap on composting.

3.1.6.4. Natural resource mmanagement recommendations

Natural resources management research directions:

- Identification of site specific and efficient physical soil and water conservation structures
- Identification of site specific and efficient plant species for biological conservation measures
- Investigation of problems associated with low tree seedling survival
- Adaptation trial for new multipurpose agro-forestry species.
- Surveying and mapping soil fertility status of the districts
- Establishing soil test based chemical fertilizer recommendation guidelines to the districts
- Identification of best *Rhizobia* species for major pulse crops
- Identification of vermi species, establishing vermi-compost preparation and application guidelines
- Identification of the optimum combinations of organic and inorganic fertilizer application

Natural resource management development proposals

- Awareness creation on integrated land management
- Modernizing spate irrigation
- Introducing zero grazing: cut and curry system
- Introducing multipurpose agro-forestry species

- Emphasis on enrichment of area closure
- Mountain development
- Introduction of blended fertilizers based on soil test.
- Expanding efficient use of organic fertilizer (manure, crop residues, mulch)
- Bio-fertilizer provision and expansion
- Expansion of appropriate composting practices
- Introducing vermi and expanding use of vermi-compost

3.2. North Western Zone Tigray

3.2.1. Description of the Area

3.2.1.1. Geographical location and agro-ecology

Based on the information from Ministry of Agriculture and Natural Resource (MoANR) North Western Zone of Tigray is located between 13.39º -14.89º N latitude and 37.34º -38.73º E longitude. About 45.46% of the area of the zone is categorized as mid land and 54.54% as belonging to low land agro-ecology (Table 7) (OoARD 2016).

Table 7**.** Geographical location and agro-ecologic coverage of the study districts

Districts	Geographical location (^{0}C)		Agro-ecology (%)		
	North	East	High land	Mid land	Low land
Tahtay-Adiyabo	14.05-14.89	37.34-38.17	0	5.87	94.13
Laelay-Adiyabo	14.08-14.69	37.89-38.46	0	39.43	60.37
Asgede-Tsimble	13.73-14.21	37.59-38.31	0	45	55
Medebay-Zana	13.68-14.33	38.30-38.58	0	60	40
Tahtay-Korar o	13.9-14.27	38.05-38.45	0	77	23
Tselemti	13.39-13.88	37.76-38.73	2.65	19	78.35

Source: Survey result (OoARD 2016)

3.2.2. Climatic condition and major crop commodities of the zone

Based on the secondary data obtained from North Western zone office of agriculture and rural development districts , temperature ranges between 18-40^{0}C while rainfall ranges between 450-1370 mm (Table 8).

Table 8**.** Average temperature and average rainfall of study districts

Districts	Average temperature (^{0}C)		Annual average rainfall (mm)	
	Minimum	Maximum	Minimum	Maximum
Tahatay-Adiyabo	38	40	450	550
Laelay-Adiyabo	27	39	605	1370
Asgede-Tsimble	25	35	500	900
Medebay-Zana	27	29	600	900
Tahatay-Koraro	18	27	800	1000
Tselemti	24	39	650	800

Source: OoARD of each district 2016.

The major crops grown in the lowland and midland areas are sorghum, sesame, finger millet and maize where the proportion of local is higher than the improved in all the crops except sesame where one fourth of sesame sown is using the improved seed. The productivity of the improved was higher than the local cultivars (Table 9).

Table 9**.** Area coverage of major crops grown at low and midlands of North Western zone.

Crop type	Area (ha)			Proportion (%)		Productivity (qt ha^{-1})	
	Local	Improved	Total	local	Improved	local	Improved
Maize	38783.5	2935	41718.5	92.96	7.04	35.67	42.99
Sorghum	74681.07	906.5	75587.57	98.80	1.20	33.87	35.83
Sesame	26585.56	9708.75	36294.31	73.25	26.75	6.49	7.92
Finger millet	46025.5	250	46275.5	99.46	0.54	24.01	30.00

Source: OoARD of each district 2016.

3.2.3. Farming system and natural resource management

The farming system in the study districts is crop dominant mixed crop-livestock production system which still follows the traditional farming system. On the other hand, the lowland areas of the zone have begun commercialized farming.

3.2.4. Socioeconomic set up

3.2.4.1. Land holding, use and soil type

Based on the secondary data obtained from North Western zone office of agriculture and rural development districts, land covered by forests take greater share compared to the other land use types. The individual farmers land holding size at highland and midland areas of North Western zone is smaller compared to the low land areas. Based on the group discussion results, male households have larger land size with more number of plots than female households. The most common source of labor in the lowland areas of the zone is both hired and family labor; while in the highland and midland areas, family labor is only used. Besides, during the peak seasons of farming (especially at weeding and harvesting time), farmers used special labor arrangement mechanisms, called "*Lifinti* and *Wofera*" i.e. farmer groups work together for a household and

then on another day for other households. Economically better-off households also engage hired labor during peak seasons of farming (Table 10).

Table 10**.** Land use area, coverage and proportion of each district

Land use type	Tahtay-Adiyabo		Laelay-Adiyabo		Asgede-Tsimble		Medebay-Zana		Tahtay-Koraro		Tselemti	
	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
Cultivated land	65788.75	14.86	48170.00	27.79	57553.00	23.49	25547.00	24.21	18577.0	25.53	37368.00	13.49
Forest land	98865.35	22.33	92104.00	53.13	56000.00	22.86	41020.00	38.87	24183.0	33.24	198639.00	71.70
Grazing land	163764.82	36.98	15489.50	8.93	7544.00	3.08	23512.00	22.28	10298.0	14.15	9727.00	3.51
Home stead	20099.75	4.54	17172.75	9.91	67903.00	27.72	1605.00	1.52	6538.00	8.99	4892.00	1.77
Others	94319.10	21.30	422.25	0.24	56000.00	22.86	13850.00	13.12	13156.0	18.08	26406.00	9.53
Total	442837.77	100.00	173358.5	100.	245000.0	100.0	105534.00	100.00	72752.0	100.00	277032.00	100.00

Source: OoARD of each district 2016.

3.2.4.2. Livelihood strategies of households

Mixed crop livestock production system is the primary production system in Northwestern zone. Short and variable rainy season in the districts are tackled by sowing early maturing crop varieties, practicing moisture conservation activities, and establishment of forest areas. Farmers in the area also collect residues of different cereals as livestock feed, and reducing their livestock number as the major activities for survival strategies during drought season. Disease and pest outbreak in the districts are prevented using chemicals, vaccine and isolation for livestock while for crops they used crop rotation, using resistant varieties, weeding, burning crop residues, and agro-forestry practices. Most of the crops used for food in the study areas are farm products and Sorghum is dominant crop in the districts.

3.2.4.3. Agricultural knowledge and information system and technology factors

Different trainings are offered in the zone focusing on crop management (row planting, fertilizer application, and weed and pest control), beekeeping, and human nutrition, etc. But, most of the time, the trainings offered are theoretical and focus on single topic and participants were the same group in each and every trainings. However, training on marketing, farm record keeping, and post-harvest losses management are not given so far in the districts. Besides, organized market information center is not available and some farmers receive market information through mobile and asking relatives but the final decision is often made by the wholesaler.

Cooperatives that support production and marketing are available in each district and/or Tabia's although cooperatives are mainly focusing on fertilizer supply, purchasing and selling farm products. Institutions that supply fertilizer, improved seed, improved farm implements and chemicals are available in these districts though they do not meet the demand of the farmers particularly improved seeds and agro-chemicals. All Tabia's in the districts are connected through rural roads to their respective district centers and currently, all-weather roads are not fully available.

3.2.4.4. Gender roles and decision making

Based on the group discussion results, both men and women participate on crop production activities during land preparation, weeding, harvesting, threshing, measuring yield and selling products. They also participate in different irrigation activities. On livestock production especially women participate in cleaning animal barns, feeding, and both participate in animal feed collection. Soil and water conservation practices are performed by men and women but men also participate in protecting area enclosures.

Most of the agricultural products (crops and livestock) and land are owned and controlled by both sex. Decision to selling of crop products and livestock is made through discussion and

agreement of both parties with the exception of milk and its products, egg and chicken that are sold only by women.

3.2.4.5. Food preparation and nutrition

Based on the survey results, the main food crops utilized in the zone are sorghum, finger millet, maize, tef, rice and chickpea and some vegetables and fruits (onion, tomato, pepper, leafy vegetables, mango, banana, papaya and guava). The major meal type consumed in the district are *injera* (composition of sorghum with teff, sorghum with finger millet and sorghum only), *Kicha* (flat-thin bread) from sorghum and maize; and stew (chick pea, faba bean, potato, pepper, milk, egg, and tomato). Most farmers obtained their food source from own farm production though some depend on aid and from the market.

Age and status based nutrition is poorly practiced. Infants (age less than two years) and age between 3-5 years) get no special attention during feeding. Lactating, pregnant women and productive age group ranging from 16-65 years were not receiving any additional balanced diet. But, the mothers during weeks of parturition get some additional diets like 'Genfo' (made from sorghum, finger millet or tef), butter and oil though traditional. Even though, the farming communities received nutrition based training and demonstration by health offices of the districts; mostly, they do not prepare different balanced diets for different age classes. In the group discussion farmers raised that food perishability is not a common problem but sometimes *injera* prepared from sorghum is easily spoiled. Besides, though farmers have access to milk and egg, they don't commonly use in their daily diet rather they sell them for earning income.

The main prioritized nutritional security constraints and problems

The following nutrition security constraints and problems in the North Western zone are listed in their order of importance:

- Unbalanced feeding habit in the community
- Skill and knowledge gap of balanced diet

- Poor attention to preventing malnutrition
- Unknown nutrient density of the existing commodities of farmers
- Theory based nutritional demonstrations and trainings
- Lack of organized institutions working on nutrition improvement

Research themes for food science and nutrition

- Research on food processing, storing and handling for crop products and searching alternatives for animal protein sources as they are becoming expensive.
- Determining best diet (crop or livestock produce) for age categoriesy from the perspective of crop and livestock products. This might require studying the chemical composition and anti-nutritional factors of improved varieties (sorghum, sesame and Finger millet).

3.2.4.6. Input and credit sources

Most of the inputs like improved crop varieties, high yielding exotic breeds and agricultural implements used in the districts are costly besides to low supply. Some of the inputs including improved varieties, exotic breeds and pesticides that are provided to the farmers do not reach to the sites on time. However, to cover their cost of production, farmers received credit service from Dedebit Credit and Saving Institution (DCSI), farmers' multi-purpose primary cooperatives and saving and credit cooperatives. Nevertheless, the interest of the farmers to get loan from DCSI is low due high interest rate while the credit provided by the cooperatives is based on membership status. Input, when available, are distributed to farmers from their respective districts and Tabia's primary cooperatives.

3.2.4.7. Agricultural mechanization and rural energy sources

It was learnt from the focus group discussions that the study areas has cultivable land suitable for mechanized farming like use of row-planter, combine harvester, tractor and tie ridger (water

conservation activities). Regardless of its suitability for agricultural mechanization, farmers in the area did not applied mechanized farming during land preparation, planting, weeding, harvesting, threshing, processing and storage. Instead they follow their traditional agricultural practices of land preparation using oxen or camel. The farmers did not prioritize the farm operations based on time, labor and expenses for land preparation, weed management, harvesting and threshing.

Pre and post-harvest handling are also traditional. Farmers store their produce in a structure called '*Gotera'* or in sacks made from leather and products are kept inside their home aside their beds. Post-harvest losses due to insect or rodent damage are also huge because of no proper storage facilities.

The main energy sources existing in the districts for cooking, boiling and baking are wood, dung and charcoal. But, movable solar energy, kerosene and battery are also commonly used as source of light. However, the available energy source here is not satisfying the farmers, this due to scarcity and availability alternative energy source and the available energy sources (movable solar energy) are used for lighting. For agricultural practices like water uplifting and drying, they don't use also any alternative source of energy. Regardless of low supply of energy sources, the farmers demand for improved energy sources is still low; because the introduced sources of energy have not maintained easily and sustainable serviced.

3.2.4.8. Climate change

The farming community in the study areas perceived the decrease in rain fall amount and an increase in windy condition from year to year. An alarming increase in temperature due to high deforestation was also observed i.e. farmers experienced unexpected winds, sudden and erratic rainfall, and reduction of water bodies from time to time. This change will definitely have negative impact on the agricultural production of the study zone. Furthermore, they get information about climate change from their experts of the district office of agriculture and development agents.

3.2.4.9. Market and infrastructure

Based on the results of focus group discussion, the price of major crops (sorghum and sesame) in the districts is low and also decided by the buyers. Perishable livestock and crop products like milk and vegetables at peak production times are also not sold at reasonable price because of lack of transport. When there is excess milk, they process it in to butter to reduce milk perishability while the vegetables becomes out of use. Regarding to infrastructure of the districts, all Tabia's have access to rural roads and are connected to the center of the district but only during dry season. Limited road access forced farmers to sell their produce at low prices.

3.2.4.10. Constraints in technology transfer

Participants in the discussion rose that there are many agricultural technologies (improved seed, agricultural machineries and improved agricultural practices) that could be introduced to the farming community. The main sources of technologies are offices of agriculture and rural development for rain-fed and livestock production. However, the local market is also main source of technologies for irrigation production. The technology transfer methodology is mainly top-down approach where the main channel used for technology transfer is mostly conventional. The information related to new technology is transferred to development agents and local administrators through trainings and verbal orientations. Then after, the local administrators and development agents of the respective Tabia's are expected to transfer the information related to the new technology to the whole community. However, some stakeholders like agricultural research centers and universities demonstrate technologies directly onto few farmers in clusters. Practically different constraints prevent the transfer of these agricultural technologies to large number of farmers. The major constraints in technology transfer are prioritized as follows:

- Poor linkage between research and extension
- Lack of working modality
- Trainings and orientations are mostly limited to farmers in administration position without considering the contribution of the trainee. Besides, most of the trainings do not considered gender.

- Demonstration and further popularization of agricultural technologies to the farmers is very low due to lower technical assistance by the extension experts at field level.
- Less emphasis given to farmers' cooperatives for their contribution in agricultural production as most training provided were focusing on marketing and cooperatives services.

3.2.4.11. Skill and knowledge management constraints

According to the farmers' focus group discussion, there are different sources of knowledge and skill and which could help them in improving their livelihood. Some of these sources are formal training, field days and experience sharing, media (Radio and TV) and personal observation. The most common skill and knowledge to be obtained from these sources are packages in agricultural production, storage and marketing. However, there are limitations in catching-up and applying these skills by the farming communities because of many constraints. Some of the constraints are listed and prioritized as follows:

- The trainings provided are theoretical based not on practical basis
- The skill and knowledge transfer methods lack focus (too much at short time period)
- Few farmers trained repeatedly
- Inappropriate selection of trainers
- Low attention to gender issues
- Training on marketing and cooperatives in agricultural production and products to local farmers is not common as other issues.

3.2.4.12. Socioeconomic and policy constraints

The study indicated that there are opportunities regarding implementation of the recommended policy directions, understanding the existing socio-political setups, and the availability of ample resources. But regardless of these opportunities, there are constraints which prohibited successful achievement as per the plan. Some of these constraints are:

- Less attention towards livestock development policies and programs

- High cost of inputs such as improved seed, fertilizer, chemicals and veterinary tools and equipment
- Incomplete market access
- Low attention given to gender mainstreaming in training and in community decision making
- Weak integration among governmental and non-governmental institutions, civic associations and cooperatives
- Weak practicability of the policies and strategies for different aspects in its implementation at the ground
- Shortage capital or financial sources and higher interest rate by loan providers

3.2.4.13. Socioeconomic and future policy considerations

It is important to design future policy directions and considerations to address the constraints facing the socio-economic and policy aspects. Hence, the following future policy directions are necessary to be considered.

- Attention should be given to livestock development policies and programs: strengthen all stages from grass root up to higher levels.
- Addressing the high cost of inputs: it is important to enhance market structure, infrastructure and competitiveness.
- To improve the availability agricultural inputs, more actors should be encouraged to enter into the market. and its infrastructure should then be attractive for their business
- The training and community decisions should give due attention to gender so that members could freely discuss and decide with no influence of others.
- The integration among different institutions and associations should be strengthened to address the individual challenges.
- Every policies and strategies need proper implementation that could be seen on the ground.
- Farmers Training Center (FTCs) found in each Tabia must be strengthened and should serve as demonstration and training centers for introduced technologies. Experience

sharing among farmers is also important as a means of technology and best experience transferring systems.

- Capacity development systems be better outlined and performed at different stages up to farmer level.
- It could be also better if, credit providing institutions established/strengthened to provide credit services at lower fares.

3.2.5. Crop production

Based on the secondary data obtained from the respective offices of agriculture and rural development districts of North Western zone of Tigray, regardless of the productivity of crops, almost all the farmers used local cultivars.

Table 11. Area coverage of major crops grown at highland and mid land areas of North Western zone Tigray

Crop type	Area (ha)			Proportion (%)		Productivity (t ha^{-1})	
	Local	Improved	Total	local	Improved	local	Improved
Linseed	255	0	255	100	0	0.65	-
Nuge	533	0	533	100	0	0.6	-
Chick pea	2378.5	0	2378.5	100	0	1.588	-
Teff	24373.5	8562.75	32936.25	74	26	1.241	1.507
Faba bean	719.75	0	719.75	100	0	2.2	-
Rice	0	1862	1862	0	100		6.206

Source: OoARD of each district 2016

3.2.5.1. Rain-fed crop production system

According to the farmers' focus group discussion, sorghum, sesame, finger millet and maize are the major crops grown in rain-fed season in low land areas of the study zone. The average productivity of the improved varieties of sorghum, sesame, finger millet and maize are 1.64, 0.54, 1.0 and 3.1 t ha^{-1}, respectively, while the average productivity of the local cultivars of sorghum, sesame, finger millet and maize are 1.95, 0.4, 1.51 and 2.1 t ha^{-1}, respectively. The level of satisfaction of farmers on productivity of local sorghum cultivars (Dagnew, Merewe, Tsaeda chumurey, Bazena, Tewzale Wediaker, Ganseber, Wedihidar and Zerie Gebru) is low.

Similarly, the perceptions of farmers' on the improved sorghum varieties (Gambela, Dekeba, Melkam and Teshale) are also low.

The level of farmers' perception on productivity of local sesame cultivars (Bawenji, Hirhir, Tegin, Gumero, Gojam and Sanduk) and improved sesame variety (Setit-1) are low. Similarly, the perception of the farmers for local finger-millet (Waliye, White and Red finger-millet (Gobezay) are also low. In addition, the farmers' observation for local maize cultivars (Asgedom, Berihu, Asgedom, Abat, Wedi-Arbea and Chenger) and improved maize varieties (BH-543, BH-545, cat man, QPM varieties, Zama, Toga and Hawassa) are low.

The major crops cultivated in the mid-land areas of the North Western zone are sorghum, finger millet, maize, tef and faba bean. The average productivity of local tef and faba bean cultivars are 0.63 and 1.5 t ha^{-1}, respectively, while improved tef variety yields an average of 1.24 t ha^{-1}. The local cultivars of tef grown in the study zone are Red and White tef (Abat), Zagure and Sergen and the improved varieties grown are Wefey, Kuncho and Kora. In the group discussion, however, farmers perceived that the productivity of both local cultivars and improved teff and faba bean varieties are low.

Farmers do not use improved seed for rain-fed crop production due to:

- Lack of continuous supply of seed
- Costs of improved seeds is very high
- Improved seeds require full package
- Improved sorghum varieties for instance (Gambela) is not good for consumption as Injera
- Knowledge gap on the importance of improved seeds (demonstration activities)
- Few demonstration activities during improved seed introduction
- Weak linkage between institutions (research center and district offices of agriculture and rural development).

3.2.5.2. Rain-fed soil fertility and conservation management practices

The farmers in the study North Western zone used chemical fertilizers (Urea and DAP), organic fertilizer (compost, farm yard manure and cow dung) and agricultural practices (crop rotation, fallowing, inter cropping) and '*tsibra'* (temporary barn for their livestock around the homestead to collect excess manure) for soil fertility management. Regarding soil and water conservation practices, the farmers also follow appropriate ploughing system (cultivate the farm land across the gradient), plant and conserve different agro-forestry trees (like momona, Guava, Mekie, *Cordia africana* and Akuma) and are engaged in physical soil and water conservation practices (such as terrace, soil and stone bund), and guiding flood water into the farmland. These exercises conserve soil nutrients, soil and water which has implication for soil fertility management.

3.2.5.3. Main challenges & constraints in the rain-fed crop production

The major rain-fed crop production challenges and constraints in relation to input, production, processing and marketing in the study area are listed below.

- Disease and insect pest (stalk borer, root rot, shoot fly, termite)
- Invasive weeds (*Striga*, *Ajeratum*, Wazwazo)
- High cost of inputs (fertilizer and improved seed)
- Lack of improved agricultural machineries and associated know-how (tractor, row planter, thresher, storage structures and harvester)
- Market problem for farm products (maize, sorghum and sesame)
- Technical gap on fertilizer application and management of introduced improved seeds
- Shortage, high price and ineffectiveness of chemicals
- Introducing crop varieties that can't adapt to the environment
- Improved seed short in supply
- Pest problem for sorghum at storage
- Water logging
- Poor agronomic management practices (farmers not using recommended fertilizer)

3.2.5.4. Irrigation crop production system

In North Western zone, irrigation is becoming a common practice and farmers are using irrigation to produce cereals (mostly maize), vegetables and fruits. Irrigation enabled farmers to produce twice a year. Furrow Irrigation (for vegetables and maize), border irrigation (for cereals), point irrigation (for fruit trees) are the most common in the study area. Water uplifting devices like triddle pump and diesel motor are commonly used. The source of water is mainly from ground water, canal diversion from spring water, check dams, private and communal ponds and shallow wells. The method of water application is gravity type furrow irrigation system. Tomato, onion, and pepper, garlic and leafy vegetables are produced. Fruits such as banana, papaya, guava, orange and mango are also produced. Fruit trees cover the largest share of the production and are the largest income generating commodities in the study zone. Water is applied when soil is dry or starts to crack. Women participate in all irrigation activities.

Improved onion varieties (Adama Red and Bomboy Red and Kesela) give 130 qt ha^{-1} and this productivity is perceived as medium. The local tomato cultivar (*sembersana* and *Timbil*) also provides 150 qt ha^{-1} and improved varieties (Melkasalsa and Roma VF) were also introduced to North Western zone. Similarly, local cultivars of pepper (*Shirba*, *Semema* and *Weldibe*) have an average productivity of 2.4 t ha^{-1} while there is an improved variety known as Markofana. The improved mango varieties such as Apple-mango, Tommy Akins and Kent were also introduced in the irrigated areas of the districts.

3.2.5.5. Irrigated agriculture challenges and constraints

Even though the farmers in North Western are practicing irrigation, they encounter many challenges associated with input supply, production, processing and markets. These are:

- High fertilizer and seeds cost
- Diseases and insects (gummosis, die back, root rot, blight, aphids) and fruit dropping in Mango.
- Limited access to water for irrigation during the dry season

- Technical gaps in irrigation method, time and watering frequency,
- Limited practice of integrated inorganic and organic fertilizer use
- Lack of agro-processing
- Market constraints (low market price of products)
- Perishable nature of vegetables and fruits
- Free grazing
- No credit service for motor pump
- Labor intensive of agriculture
- Lack of skill and knowledge in irrigation
- Poor design of irrigation structures and check dams
- Lack of technical support and follow-ups for farmers (particularly in Tekeze) and
- Bird attack in mango during maturity stage.

3.2.5.6. Crop production recommendations

Crop research proposals:

- Moisture stress tolerant crop varieties (especially sorghum)
- Identifying disease and pest resistant crop varieties (sorghum, sesame and finger millet) specially to (Rust, striga, stock borer, armyworm and smut)
- Multiplication of pre-basic and basic seed ofthe major crops by farmers
- Introducing and adopting appropriate farm implements suitable for the major crops (row planting, weeding, harvesting and threshing).
- Introducing soil test based fertilizer type (blended) on time and deliver scaling-up training to farmers about the rate, time and type the fertilizer application.
- Introducing integrated soil fertility management (bio fertilizers, chemical fertilizers and organic fertilizers)
- Capacity building in post-harvest handling and value addition (to reduce post harvest losses and stabilize market price)

Crop developmental proposals

- Supply of chemicals and pesticides at community level with appropriate packaging size and sprayers which could be affordable for individual farmers and available at least in the farmer training center .
- Capacity building on disease and pest management skills and use and methods of fertilizer application
- Sustained supply of improved seeds.
- Skill gap filling on agricultural farm implement operation and management and sustainable supply of improved farm implements
- Supplying blended fertilizers, bio fertilizer, vermin compost, and gypsum
- Skill gap filling in soil fertility management concepts and practices
- Creating and empowering local credit and saving institutions for crop productions (improve seed, fertilizer and mechanization farm implements)
- Giving attention and control to the invasive exotic weed specially striga
- Capacity building on seasonal crop productions to control market fluctuation and create awareness about climate change.

3.2.6. Livestock production

Based on farmers' group discussion results, animals such as cattle, small ruminants, poultry and equines are the major livestock typesin the North Western zone of Tigray region. The livestock population in the study zone is 1,922,107, 1,803,123, 219,691, 2,462,627, 252,401, 21,720 and 79,832 goats, cattle, sheep, poultry, equines, camels and bee hive, respectively (CSA 2016). Llivestock production in the study area is constrained by shortage of feed and water, disease and external parasites and poor quality breed.

3.2.6.1. Livestock types

Begaits are the dominant local breeds in all types of ruminants (shoat and cattle). Unidentified local sheep breed called *Emala* (particularly in Tabia Ziban-Gedena) and a cross between Arado and Begait cattle is also found in Northwestern zone. Local chicken breeds are dominant in the

districts of the study zone although different exotic egg types are introduced. The farmers in the districts don't rear improved breeds due to low adaptability to the environment, susceptibility to different diseases, supply and knowledge gap on importance of these breeds, and the exotic breeds require intensive management which is not currently practiced by the farmers. The farmers demand for improved poultry breeds is low due to low supply, their rearing system is difficult for the farmers and low disease resistance than the locals.

Table 12. Major local and improved breeds of livestock in North Western zone of Tigray

Species	Breed	Exotic	Purpose of keeping
Goat	Local	--	Income, consumption & manure
Cattle	Arado Begait	HF	Traction power, milk, manure and income
Poultry	Local	Rhode Island Red, Bovines Brown, Keokok and Fayomi	Selling For egg and meat consumption
Sheep	Local		Income, manure & consumption

Source: Survey result 2016

3.2.6.2. Livestock productivity

From the focus group discussion, it was found out that the average milk production of cattle is about 1.5-4 and 7-10 liters per day for local and improved cow, respectively. Besides, the mean butter production for local cattle is 0.25-1.2 kg per week per head. The overall perception of farmers on milk production is low for local but high for improved breeds; while for the butter productivity they perceived as low for both local and improved breeds. The average egg production of chickens is 144 and 312 eggs per year per head for local and improved breeds, respectively. Farmers have high perception on improved poultry breed egg productivity whereas low for local poultry breeds.

3.2.6.3. Livestock rearing purpose, breeding and feeding techniques

As it is indicated in the above (Table 12), small-ruminants in the districts are reared for selling, manure and meat consumption purposes, large-ruminant cattle are reared for traction power,

milk, manure and market purposes. Moreover, poultry production is mainly practiced for selling egg and live chicken, and consumption purposes.

The breeding mechanism practiced by the farmers in the districts is mostly uncontrolled breeding system almost in all animal species. But some farmers, especially those having high number of animals, use selected male as sire based on own performance and mother's performance. In addition, selecting improved cock in poultry production is becoming common in numerous farmers. Knowledge gap about inbreeding, ineffectiveness of AI, and shortage of supply of improved breeds enforce the farmers to practice uncontrolled breeding systems on ruminants.

In the study area, free grazing and browsing feeding systems are common in cattle and small ruminants. Locally available cereal straws (sorghum stalk and grass hay) are also common feed particularly during dry season. In some cases, farmers introduced forages (*Sesbania*, *Lucinea*, elephant grass, pigeon pea, alfalfa and cowpea). Chicken are reared through scavenging feeding system in the districts. In feeding all animals the farmers didn't use feed trough which leads to feed wastage. Considering gender and livestock production, ownership and decision making in poultry and its products is controlled by women while decisions on cattle and shoat are made by discussion. Women also participate in animal feed collection and cleaning barns.

Reasons for not using improved exotic breed are:

- Adaptability problem to the environment
- Susceptible to different diseases particularly in poultry production
- Lack of supply and knowhow on exotic breeds
- Because local breeds require less amount of feed
- Most of the farmers use exotic breed in poultry production although they have adaptability and disease sensitivity problem
- Exotic cattle breed can't use for traction power
- Cost of the exotic breed is very expensive
- Demands intensive management

3.2.6.4. Prioritized and screened livestock production problems

Animal feed collection and cost of medicine in animal production are considered as the most tedious, costly and time-consuming activities in the district. The major livestock production challenges and constraints related to input, production, processing and market in the districts are:

- Animal feed shortage and quality
- Livestock diseases and poor animal health delivery system (vaccine, drugs and veterinary equipment's)
- Problem related to improved breeds and the breeding system.
- Very low attention by governmental to livestock development
- Shortage of improved machineries (chopper and beller) for processing feed.

3.2.6.5. Livestock production recommendations

Livestock research proposals:

- Introducing technologies, methods and procedures on improving quality and utilizing of locally available animal feeds
- Introducing and adapting improved forage species
- Identifying and characterizing the current animal diseases on each species i.e. understanding the symptom, severity and transmission methods of the disease
- On-farm and on-station characterization of indigenous cattle, sheep, goat and chicken breeds and recommending for specific purposes (milk, meat, power, export and local market)
- Designing proper breeding strategies for each species and particular area.

Livestock developmental proposals:

- Giving attention to livestock production system i.e. extension experts and DAs at district and Tabia level must be involved in activities related to livestock production only.
- Building animal health and nutrition laboratories at zonal level
- Distributing proper vaccination for all animal species and assessing the effectiveness of AI

- Expanding livestock related technologies and procedures to beneficiaries
- Strengthening agricultural inputs supplying institutions at all levels
- Capacity building for developmental agents and other stakeholders

3.2.7. Natural resource management

3.2.7.1. Common property resource and their management

The farming community in North Western zone has experienced different methods of sustainable land management such as integrated soil and water conservation which includes the following.

a. Semi-circular bunds with stone embankments are a semi-circle shape with the tips of the bunds on the contour. They are used mainly for rangeland and bush land rehabilitation. They also serve as points of ground water recharge. The technique is also used for growing trees and shrubs. Hhalf-moon structures are constructed in some degraded area of the district.

b. Check dams structure noticeably covers large area particularly large and degraded gullies. These structures are successive and constructed along the various water courses of the catchment all the way down the slope. The community has constructed check dams with bundles of stones and gabions cemented with mud. The aim is to rehabilitate the previously ruined gullies and in the meantime, could help to recharge the ground water and accumulate sediments.

c. Stone bund are constructed following the contour of a watershed. The main purpose is to reduce the slope length, slow down and filter runoff, thereby increase infiltration and capture sediments. These structures are most reliable engineering structures in terms of cost because of they are constructed with locally available materials such as stone and soil. The unreserved effort of the community and their free service (at least 20 days per year) is showing a promising result in sustainable watershed management.

d. Area enclosure is communal property the farmers in the district don't have sense of ownership i.e. they always require responsible individual for keeping from grazing and other human interventions.

3.2.7.2. Soil characteristic and management

The major soil types in the zone are classified as loam, sandy and clay. The classification is based on soil color, water holding capacity (WHC), crop specific watersheds and topographic position of the land. Among these, clay soil has high area coverage relative to others. Soil salinity is not a major problem in the zone. The farmers in the district believe the deterioration of soil fertility. Hence, they practice *tsibra* method (barn the livestock around the cultivated land), applying inorganic and organic fertilizer, inter-cropping, crop rotation, and fallowing practices which could enhance soil fertility. They also apply

- agro-forestry practice with species like *Faidaherbia albida*, Guava, Lehay, *Cordia africana*, Gumoro, Chugono, Sesbania, Lucinea and have recently introduced neem and elephant grass.
- biological soil and water conservation
- Across the gradient cultivation for conserving soil fertility (terrace, soil bund, stone bund).

3.2.7.3. Climate change

Based on farmers' group discussion results, farmers in the districts feel the presence of climate change. They expressed this phenomenon in terms of reduced amount of rainfall, shorter and variable in rainy seasons. Besides, they perceive as some forest species are endangered (reducing forest coverage). Farmers in the zone get climatic information through their respective kebele and district experts, and also from radio.

3.2.7.4. Natural resource management constraints and challenges

- Lack of proper design in soil and water conservation structures
- Ssedimentation as most of the time structures like gabion check dam are not effective.
- Lack of awareness and sense of ownership in common properties management;

- Prioritizing problem in constructing soil and water conservation structures in a given watershed
- Agricultural expansion; recently, the growing concern of agricultural mechanization and market-based production system is forcing conversion of forest areas into cultivation and it consequently resulted to a complete destruction of economically valuable forest species like *Bosowela paprifera*.
- Blended fertilizer, soil test based fertilizer application, vermi compost technology and integrated use of organic with inorganic fertilizers and cover crop are not yet introduced. Most farmers apply much amount of compost on the farm land. However, there is limited technical gap for the appropriate preparation and application.
- The community is used to applying inorganic fertilizers but not in the recommended rate, usually Urea and DAP on the major crops.
- Appropriate rate, method and time of application of fertilizers are not take in to consideration. These all challenges aggravate nutrient loss and lead to burning effects for all crops.
- Shortage of materials in soil and water conservation activities especially during community work.

3.2.7.5. Natural resource constraints and crop production interrelationships

From the group discussion it is found that, poor irrigation practices, poor technical backstopping of soil and water conservation practices which are not supported through biological methods are the major constraints in the study zone. Thus, the explained constraints directly affect the agricultural production negatively by reducing soil fertility, loss of soil organic material and leaching of soil minerals. The farmers also witnessed the knowledge gap on improved soil and water conservation practices in the zone. Free grazing affects natural resources including area enclosures. Farmers in the district also use livestock by-products to improve soil fertility like farm yard manure, and *Tsibra*.

3.2.7.6. Prioritized and screened natural resources management problems

Problems associated with natural resources management in the districts are:

- Land degradation
- Flood hazards
- Recurrent drought
- Indigenous tree species extinction
- Low tree seedlings survival
- Knowledge and technical gap on soil and water conservation measures
- Shortage of construction materials (gabion and cement) for conservation of spate irrigation and other physical conservation measures
- Free grazing

Prioritized soil fertility problems

Problems associated with natural resources management in the districts are:

- Removal of top soil
- Soil nutrient depletion
- No soil test-based fertilizer application (blanket fertilizer recommendation)
- Expensive cost of chemical fertilizers and no supply of bio fertilizer
- Poor management of organic fertilizer (manure, compost, mulch and crop residue)
- Poor agronomic practices (shifting cultivation and intercropping)
- Shortage of composting materials and technical gap on composting practices.

3.2.7.7. Natural resource management recommendations

Natural resources management research proposals:

- Determining the rate of organic and inorganic fertilizer for major crops
- Assessment of the impact of organic and inorganic fertilizer for soil management and agricultural production

- Identification of site specific and efficient physical soil and water conservation structures
- Identification of site specific and efficient plant species for biological conservation
- Investigation of problems associated with low tree seedling survival and the way how to enhance seedlings survival rate
- Adaptation trial for new multipurpose agro-forestry species.
- Surveying and mapping soil fertility status of the study areas
- Identification of the optimum combinations of organic and inorganic fertilizer application to major crop types
- Vermi compost technology introduction for soil fertility enhancement.

Natural resource management developmental proposals

- Establish excellence centers for technology transformation
- Create awareness for appropriate compost preparation and rate
- Creating awareness about the merit of blended fertilizer
- Establishing soil-test based inorganic fertilizer recommendation guidelines to the district.

3.3. Western zone of Tigray

3.3.1. Geographical location and agro- ecology

Western zone Tigray is situated between 13.35 - 14.45^0 North latitude and 36.28 – 37.81^0 East longitude. The study zone is bordered on the east Northwestern, the south Amhara regional state, and the west by Sudan and on the North by Eritrea. This zone has three rural and one town districts namely kafta humera, Welkayt and Tsegedie, and setit humera. This study targets three rural districts (kafta humera, Welkayt and Tsegedie) as part of the agricultural growth program. Based on the CSA (2013), rural population projection of Western zone Tigray is estimated to be a total population of 398,805 which is composed of 203,973 males and 194,832 females. The zone has lowland, midland and highland areas where the lowland, midland and the highlands represent 75.3%, 21.9% 2.7% of the land coverage of the zone, respectively. The dominant soil types of the districts of western zone are Vertisol, Luvisols and Cambisols in Kafta Humera, Welkayt and Tsegede, respectively. A summary of the eographical location and agro-ecologies of the study districts is presented in table13.

Table 13. Geographical location of the study districts

District	Geographical location (degree)		Agro-ecology (ha)		
	Longitude	Latitude	High land	Midland	Lowland
K/ humera	13.67-14.45	36.27-37.53	-	14.3	85.7
Welkayt	13.49-14.12	36.93-37.81	-	40	60
Tsegedie	13.35-13.77	36.48-37.76	8.6	21.7	69.5

Source: OoARD of each districts 2016

3.3.2. Climatic condition

According to the information obtained from the districts, the mean annual rainfall for Kafta Humera, Welkayt and Tsegedie is 700, 1250 and 1850 mm, respectively. Similarly the average temperature of the districts is also 37, 21.25 and 23.5 degrees celsiusin the same order as above. Summary of the temperature and rainfall regimes is presented in table14.

Table 14: Average temperature and average rainfall of the study districts

S.N	District	Average temperature (°c)		Annual average rainfall (mm)	
		Min	Max	Min	Max
1	Kafta-humera	25	48	650	750
2	Welkayt	17.5	25	700	1800
3	Tsegedie	12	35	1200	2500

Source: OoARD of respected districts 2016

3.3.3. **Socioeconomic set up**

3.3.3.1. Land holding, use and soil type

Western zone covers a total area of 1,433,531 hectares. The total land of each district and its land use is described in table 15. The farming system of the study area is crop-livestock mixed farming system.

Table 15. Land use, area coverage and proportion at district level

Land use type	Kafta-humera		Welkayt		Tsegedie	
	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
Cultivated land	388,880	53.61	174582.5	38.8	102509	35.31
Forest land	240,000	33.09	84672	18.8	35876	12.36
Grazing land	36,800	5.07	81121	18.1	99828	34.39
Home stead	1,715	0.24	21095	4.7	25106	8.65
Others	57,972	7.99	88213	19.6	26984	9.30
Total	725,367	100	449683.5	100	290303	100.00

Source: OoARD of respective districts compiled report 2016.

The districts have plain farmlands suitable for mechanized farming. Most of the lands are owned by the male-headed household and the activities are performed manually and with the help of machineries. During peak seasons, such as weeding and harvesting, farmers and investors use laborers who come from different corners of the country following the announcement by radio. Due to the migration of male farmers from the high lands of Welkait and tsegedie to lowlands of

Western zone of Tigray, shortage of labour (men) is persistent. For this reason, the field management is left to the wife and the kids. Hence, the farmlands in the highlands are not timely sown, weeded and no timely control of pests and diseases.

3.3.3.2. Farm household survival strategies

In the study zone, farm households engage and pursue diverse off-farm and non-farm livelihood activities to cope with natural and man-made challenges. Therefore, the farming community tried to cope to the challenge with different adapting strategies. The main coping strategies are:

- Selling their animals during food shortage period. .
- Using early maturing technologies
- Moisture conservation (soil and water conserving practice)
- Collecting crop residues for dry season livestock feed
- Reducing livestock number during drought season
- Construction of pond for water source.
- Petty trading
- Moreover, the survival strategies for disease and pest outbreak are:
    - Vaccination and treatment, using chemicals
    - Burning crop residue.

3.3.3.3. Gender and decision making roles

In lowland areas of Western zone, men dominantly participate on rain-fed and irrigated crop production such as land preparation, weeding, harvesting, threshing and selling produce. Guarding area enclosures is also an activity of men.

In addition livestock production activities like cleaning animal barns and feeding and animal feed collection are equally handled by men and women.. Moreover, Soil and water conservation practices in the area are accomplished by both sexes. Whereas in midland areas, rain-fed and irrigation activities such as land preparation, weeding, harvesting, including family management and routine house work are performed by women. Men mainly focus on lowland growing crops and during the rainy season men migrate to lowland areas to work.

Most of the agricultural products and land are owned and controlled by both gender categories. Concerning marketing of crop and livestock products, decision is made after discussion. Milk and its products, egg and poultry are particularly sold by women only.

3.3.3.4. Socioeconomic and policy considerations

- Livestock development policies and programs are not well established.
- Artificial fertilizer is costly.
- Improved seed and other input provider institutions are not established.
- Credit institutions are not enough and the interest rate is high.
- FTCs not strengthen for demonstration and training.
- Experience sharing/field day's participation among farmers is shallow

Socio economics and extension research proposals

- Demonstrating and pre-extension popularization of improved technologies
- Determining adoption and extent of adoption of improved technologies
- Studying of extension system
- Impact assessment of promoted technologies
- Studying socio-economic policy analysis

Appropriate strategies need to be adopted and adapted to address the challenges of increasing agricultural productivity and agricultural development to industrialization. A small-scale district focused model industrialization strategy is proposed that partly addresses the lack of suitable infrastructure by locating small-scale firms within their appropriate markets. Strengthening the capacity of local actors in developing agricultural implements should be given attention. Formulation and implementing policy systems that focuses on training of highly qualified professionals and researchers in a specific district.

3.3.4. **Rural institution and cross cutting**

3.3.4.1. Input and credit environment

Most of the inputs used in crop and livestock production include:

- improved seed (varieties)

- chemical fertilizer
- improved breeds (livestock)
- agricultural machineries

Inputs distributed to the farmers are expensive (fertilizer and improved technologies) and there is also shortage of the improved technology itself besides to not being available on the right time. Getting credit service to buy the required inputs is also a problem. Farmers in the districts obtain credit form different organizations including Dedebit micro finance and local credit and saving associations. The credit service is not however accessible to all farmers because of its lower availability and high interest rate. According to this PRA exercise, there are some informal credit services like shell or *haratsa* that farmers might opt whenever the formal credit services are not in a position to serve them. Similar informal conflict resolution by elders and religious leaders also exist.

3.3.4.2. Market and infrastructure

The settlements or the kebeles are organized in groups and connected by road which is advantageous for exchanging goods and services. The presence of ECX in the zone is an opportunity for sesame and mungbean crops and the producers. However, no similar markets for other crops, livestock and their products exist in the zone.

3.3.4.3. Nutritional status

Sorghum, wheat and tef are the major crops and are staples in the districts which are prepared in the form of *injera*, *kicha* and porridge. Besides, farmers in the area produce and use rice and finger millet for food. Stews used for eating with *injera* are *shiro* and *kikie* and are entirely obtained from market. Some farmers in the midlands however grow the legumes for the stew in their own farms. They rarely use animal products such as milk, egg and meat in their diet.

Farmers in the study zone prepare their meal from what they have and no special food is prepared for different age groups. Little attention given to pregnant and lactating woman and are fed meat, milk and soup.

Food preparation process

Steps of food preparation from sorghum (Fig. 5) and legumes (Fig. 6) practiced are summarized. The food preparation process from sorghum shows there is no application of dehulling process on colored sorghum varieties.

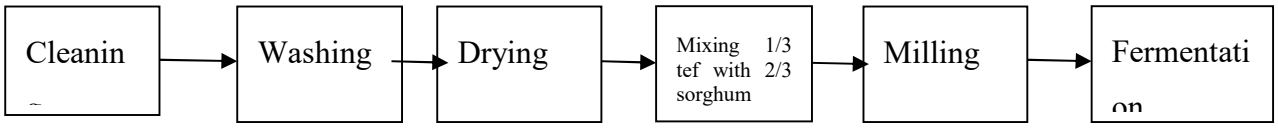

Figure 4. Steps of injera preparation from sorghum

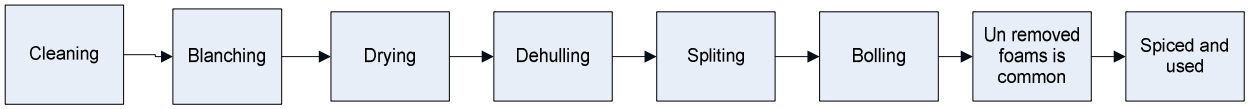

Figure 5. Steps of stew preparation from legumes

The main nutritional security constraints of the districts are:

- No institution which work on nutrition though there is little attempt by health office
- Limited training on nutrition and if any more of theory- based
- Lack of Skill and knowledge on different food staff

3.3.4.4. Rural energy sources

Energy is very vital in rural areas and town too for daily activities such as cooking, and lighting. In the study zone the energy source for baking and cooking is mainly wood and charcoal. The energy source for light is either electricity, battery and solar. The energy source for plowing land using tractors and water uplifting motors is petroleum. The problems farmers faced in the study area related to energy sources are:

- Health problem
- Deforestation
- Electricity not frequently working
- Solar and motor maintenance and supply problem

3.3.4.5. Climate Change

Farmers in the districts get climate information from Keble and district experts, mass media and some had knowledge about the climate change from their past experiences. Farmers expressed climate change in terms of:

- Rainfall fluctuation in intensity and distribution
- Reduced amount or number of water banks
- Increase in temperature
- Strong winds with dust particle from neighbor countries (Sudan).
- Loss of biodiversity
- Decreasing productivity potential
- Heath related problem due to air pollution
- Drought

3.3.5. **Agricultural mechanization and knowledge transfer**

3.3.5.1. Agricultural machineries

In the lowlands of western zone of Tigray, farmers used tractor for plowing and thresher for threshing sorghum only. The existing plowing machine (tractor drawn) has some technical draw backs such as shallow plowing depth and less weed uprooting. Farmers also use "mowled" which is a hand operated small implement used for weeding. It is a small one and its needs modification in its size, type and strength. The thresher machine is tractor drawn and manual operated. So there is no combined harvester and row planter machineries introduced which are expected to facilitate the farming operation.

In mid and high land area of the zone, small scale farmers are still using traditional animal drawn tillage system. According to this PRA exercise, farmers prioritize farm operations activities based on requirement of labor, cost and time as weeding, harvesting, plowing and threshing, respectively.

3.3.5.2. Agricultural knowledge & information system & technology factors

The method of technology transfer is chiefly top-down approach. The agricultural technologies which emanated from either from research center or other organization are transferred to the user farmers through demonstration and popularization. Agricultural technologies are transferred in both formal and informal ways. The formal ways of technologies transferred via trainings and experience sharing, field visits and exposures given by office of agriculture and Humera agricultural research center, Sesame Business Network, CASCAAP, Mekelle University etc. The informal ways are through farmer to farmer knowledge sharing and investors to farmer experience sharing.

Most trainings focused on fertilizer and improved seed and but not on nutrition, improved farm implements, marketing, water use efficiency, forestry and agro forestry, farm record keeping, and post-harvest management. Trainings on row planting, artificial fertilizer application and nutrition are focused on theory.

Organized center of market information is not available, but farmers received market information through DAs, agricultural experts, television, radio, mobile and farmer to farmer communications. Cooperatives that support production and marketing are available in the districts focusing on improved seed, fertilizer and pesticide supply and purchasing and/or selling of farmer products.

3.3.6. Farming system and natural resource management

3.3.6.1. Farming system

The farming system in the zone is mixed (crop and livestock). The lowland areas of the zone are very suitable for mechanized agriculture hence there is introduction of tractors, disc harrows and threshers for plowing and threshing. However, in the highlands and midlands there is no introduction of tractors and threshers and their only farm implements are oxen plough and sickle. Land is fragmented in the highlands and hence not suitable for mechanization.

Free grazing has an influence on crop production in terms of weed seed dissemination and soil degradation. Unrestricted free grazing also makes the soil less productive because no crop residues are left on the farm to decompose.

The cropping system of the study area is mainly mono-cropping sometimes accompanied by limited crop rotation. Farmers grow sesame year after year in the low land areas as sesame fetches good return and no problem with marketing. Crop rotation practice in the study zone is limited only to sesame and sorghum.

Communal grazing lands are vital sources of livestock feed in the study area. The zone is endowed with high number of livestock which feed unrestrictedly on the grazing land. The unrestricted access resulted in exploitation and lead to degradation of the grazing lands

3.3.6.2. Rain fed crop production

Most of the farming system in the lowland parts of the districts is dominated by mono-cropping system. There is however limited crop rotation system with sesame and sorghum. This mono-cropping resulted in poor soil fertility, disease and pest outbreak. The major crops growing in the lowland area of western zone of Tigray are sesame and sorghum. Few farmers in the districts practice crop rotation system in order to maintain the soil health. Farmers do not use enough inputs and follow proper agronomic practices. Most crops grown in highland and midland are wheat, Niger seed (noug), faba bean, finger millet and tef and farmers practice crop rotation among the listed crops. Even though, this cropping system has its own role in soil fertility improvement, the soil fertility of the district needs additional soil fertility improvement measures. To this end, farmers practiced fallowing (occasional case), apply inorganic fertilizer, compost, animal dung and barn rotation (*tsibra*) in small scale. Inorganic fertilizer and compost are not applied at recommended rates. the crop varieties grown and their productivity in the study districts are presented in Table 16, 17 and 18.

Table 16. Summary of major crops, productivity and perception in the Kafta-humera district

Major crops	Variety		Average Productivity (t/ha)		Farmers perception on productivity (Low, Medium and High)	
	Local	Improved	Local	improved	Local	improved
Sesame	Hirhir	Humera1	0.40	0.35	Low	Low
	Gojam azene	Setit1	0.43	0.48	Low	Low
	Bawnji	-	0.38	-	Low	-
Sorghum	Arfagedem	Berhan	1.33	1.5	Low	Low
	Deber	-	1.58	-	Low	-
	Dagnew	-	1.00	-	Low	-
	Wediaker	-	1.38	-	Low	-
	Tewzale	-	1.75	-	Low	-
	Wei-sbuh	-	0.6.0	-	Low	-
	Shilkuit	-	0.85	-	Low	-

Source: Own survey 2016

Table 17. Summary of major crops, productivity and perception in the Welkayt district

Major crops	Variety		Average Productivity (t/ha)		Farmers perception on productivity (Low, Medium and High)	
	Local	Improved	Local	improved	Local	improved
Sesame	Hirhir	Humera1	0.8	0.5	Low	Low
	Gojam azene	Setit1	0.7	0.6	Low	Low
	Bawnji	-	0.4	-	Low	-
	Gomero	-	0.4	-	Low	-
	Zenabit	-	0.4	-	Low	-
Sorghum	Dagnew	-	1.5	-	Low	-
	Wediaker	-	1.7	-	Low	-
	Wedi hailay	-	1.4	-	Low	-
Wheat	Gomad	-	0.87	-	Low	-
Teff	Red teff	Kunche	0.8	0.8	Low	low
	Timtim	-	0.8	-	Low	-
	Sergen	-	0.8	-	Low	-
Fingure millet	Black	-	0.93	-	Low	-
	Red	-	0.8	-	Low	-

Source: Own survey result 2016

Table 18. Summary of major crops, productivity and perception in the Tsegedie district.

Major crops	Name of variety		Average Productivity (t/ha)		Farmers perception on productivity (Low, Medium and High)	
	Local	Improved	Local	improved	Local	Improved
Sesame	Hirhir,	Humera1	0.4	0.4	Low	Low
	Gojamazele,		0.4		Low	
	Gomoro		0.3		Low	
	Mobile		0.4		Low	Low
Sorghum	wediaker,		1.25	--	Low	
	Tewzale,		1.5		Low	
	Wediarbaua		1.25		Low	
Wheat	Gomad	Canada	1.26	0.8	Low	Low
	Tewzale		1.45		Low	
Teff	red teff	kuncho	0.75	0.5	Low	Low
	Ambelay				Low	
barley	Belgi	-	0.89		Low	-
	Abat		0.95		Low	

Source: Own survey result 2016

Most of farmers in different agro-ecologies of the study zone used local planting material in their production system though there is a limited usage of improved planting material. This is because farmers did not get improved seed on time and its high cost. Farmers have also discussed that late arriving planting materials are of poor quality and probably might have stayed in store for longer time or might have come from afar distances. The farmers in the study zone perceive the productivity of both local and improved planting material as low.

3.3.6.3. Rain fed Soil fertility management

Most of the arable areas of the lowland districts have gentle slope and flat plain with more than 90% of the soil type is Vertisol (KHOoARD, 2016). This soil type getswater logged during the rainy season and cracks during dry season which makes it difficult for cultivation. But the farmers are still using disc harrow which plows not more than 5 cm deep and that creates hard pan in the lower layer of the soil that leads to water logging and prohibit free root growth. From the group discussion, it is found that crop rotation is limited. They used sesame in rotation with sorghum for years and with unspecified pattern. This poor practice of crop rotation resulted poor soil fertility and disease and pest outbreak. According to the discussion they try to mitigate their

soil fertility problem through inorganic fertilizer application. The high land and midlands restore the soil fertility through applying manure, inorganic fertilizer, crop rotation and fallowing. Farmers in Tsegede highlands for example have started application of lime to reclaim acid soils.

3.3.6.4. Main challenges and constraints in rain fed crop production

- High cost and untimely supply of improved seed
- Shortage of technical training on fertilizer, pesticide and insecticide applications practically at the ground.
- No access for pesticides, lack of access to row planter, no improved tillage equipment except disc harrow and lack of harvester.
- Disease (webworm, blight, stem borer, *Fusarium* (root rot) wilt, weevil and shoot fly)
- Inappropriate use of fertilizers
- Lack of technologies that preserve and add values
- There is no equivalent market for sesame production, which implies that profit margin is not fairly distributed among producers, middle man and sellers.
- Striga problem in sorghum

3.3.6.5. Prioritized and screened rain-fed crop production problems

- 2, 4D chemical inhibits sorghum growth and make it less productive
- Pest and disease (Striga, Meal bug, African army worm, Boll worm, Blight)
- Shortage of varieties (Example: Pest and disease resistant, high yielder and water logging resistant).
- Lack of adoption of mechanization (row planter, thresher and harvester)
- No full package application
- Lack of improved forage and different facilities that enhance quality of available animal feeds and improve utilization system.
- Lack of awareness on introduced technologies

3.3.6.6. Crop production recommendations

Crop research proposals:

- Identifying controlling mechanisms for major pest and disease (bollworm, late blight, aphides and root rot.
- Investigating management options for meal bug and bollworms.
- Introduce herbicide for sesame
- Introduce/adopt sesame non-shattering variety
- Adapting water logging resistant sesame variety
- Improving the existing breeding system
- Introduction and demonstration of farm implements (row planter, thresher and harvester)

Crop development proposals:

Focus on development and introduction of new affordable technology of farm machineries and implements (row planter, fertilizer spreader, harvester, thresher and disc plough, moldboard plough, disc Harrow, moldboard harrow, disc ridger, moldboard ridger and sprayer. Moreover, raising the general level of awareness of the farmers with the utilization of crop residues deserves further research and development intervention

3.3.6.7. Irrigated agriculture crop production

In addition to the rain fed crop production, different vegetables such as j*irjir,* onion, pepper, tomato, lettuce and watermelon are grown. Fruits like mango, lemon, banana, avocado, guava and papaya are also produced in the districts. The major source of irrigation water in Western Zone is ground water, river diversion, wells and check dams. Water is applied using gravity type furrow irrigation and some farmers also use diesel pumps for uplifting groundwater.

The irrigation frequency depends on soil type, water availability and crop type. The frequency can vary 3-4 days based on the crop stage. In irrigation women participation is poor in lowland areas while they participated in the midland and highland areas. Farmers of the study zone have indicated that the sources of the varieties of fruit and vegetables that they use in their irrigation are unknown (get them from the Sudan or somewhere else). Farmers spend their money and yet they could also be a source of inoculum of unknown disease and pest since their identity is not well known.

3.3.6.8. Irrigated agriculture challenges and constraints

In growing horticultural crops different challenges are faced by the producers. These constraints are mentioned below.

- High cost and lack of easy access to improved seed
- Shortage of technical training on fertilizer, pesticide, insecticide application
- No nearby access to pesticides and lack of suitable sprayers.
- Disease and pests (eg. Mango failed to give fruit, flower abortion, butter fly, white fly infestation, and anthracnose; Lemon fungus or die back; Tomato: bollworm, root rot, cut worm, late blight, aphides, Onion: root rot, aphides; Pepper: root rot, blight, flower abortion; Guava: insect pest attack, bird attack, and ball worm); Apple:fFruit dropping and long maturity; Papaya: flower dropping, bird attack and beet root and potato: Zememet
- Poor method of land preparation and planting.
- Lack of technologies that preserve and increase values (reduce post harvest loss).

3.3.6.9. Prioritized and screened irrigated agriculture constraints

- Long distance to market and seasonal fluctuation of market price.
- Disease and pests
- High cost and lack of access to improved seed
- No nearby access for pesticide, insecticide chemicals, and lack of motorized knapsack or sprayer
- Shortage of technical training on fertilizer, pesticide, insecticide application
- Lack of technologies that preserve and increase values (reduce post-harvest loss).

3.3.6.10. Irrigated crop production recommendations

Irrigation research proposals:

- Identifying controlling mechanisms for major pest and disease
- Introducing improved technologies that preserve and increase values
- Introduce pesticides.
- Research on appropriate pesticide and lack of motorized knapsack or sprayer
- Improving the existing breeding system

- Introduction and demonstration of improved technologies (row planter, thresher and harvester)

3.3.7. **Livestock Production system**

3.3.7.1. Livestock types

The major livestock types in western zone of Tigray are cattle, shoats and poultry, used as source of income. The study area is rich in livestock resources with the opportunities of better breeds of Begait cattle and shoats which have better meat and milk production compared to the local breeds (Arado). The productivity and farmers perception on productivity is summarized in Table 19.

Table 19. Major livestock types, productivity and perception.

Livestock types	Breed		Milk (lit/day/ head), Egg (number/mon/head		Farmers perception (Low, Medium and High)	
	Local	Improved	Local	Improved	Local	improved
Cattle	Arado		2		Low	Medium
	Begait	HF	3.67	8.53	Medium	-
Goat	Local breed	Begait	-	-	Low	-
Sheep	Local breed	Begait	-	-	Low	-
Poultry	Local breed	improved breed	11	29	Low	High

Source: own survey result 2016

Most farmers in western zone rear cattle, goat, sheep and poultry and the farmersperceive the productivity livestock as low.

3.3.7.2. Livestock production system

It is found that the livestock production system in the districts is extensive system of production and breeding and feeding practices are uncontrolled. The farmers are not benefiting from livestock production due to improper management and utilization.

3.3.7.3. Livestock rearing purpose, breeding and feeding Techniques

Farmers rear cattle, small ruminants and poultry mainly for income source and meat (consumption). In addition, they use cattle for draft power. The income obtained from livestock is through selling of live animal and/or through livestock products (milk and egg). Breeding is

mostly uncontrolled even though some farmers selecting local bulls. AI service is also poorly practiced in the districts. Feeding techniques are also unimproved as they feed their animal on ground which resulted to feed loss due to animal waste and other physical damages

3.3.7.4. Livestock production constraints and challenges

- Lack of improved feed both in quality and quantity
- Inefficient AI services
- Lack of improved breeds
- Inbreeding
- Diseases (eg. foot and mouth disease, newcastle, diarrhea, sheep pox, thick, lice, lumpy skin disease, anthrax, bloating, black leg, pastoralists, trypanosomiasis),
- Lack of awareness in animal husbandry (housing, feeding, grazing management and health aspect)
- Uncontrolled breeding
- Shortage of grazing lands and over grazing
- Lack of technologies that preserve and add values to animal products and by-products,
- Lack of market linkage: unreliable and far away markets.

3.3.7.5. Prioritized and screened livestock production problems

- Uncontrolled breeding
- Disease and pest
- Lack of animal forage in quality and quantity
- Shortage of water
- Poor AI service

3.3.7.6. Livestock production recommendations

Livestock research proposals:

- Introduction and demonstration of promising forage varrieties and multi-purpose trees
- Intercrop forage varieties with cereals
- Improving the existing breeding system
- Generation of improved forage technologies

- Assessing the prevalence of economically important disease and parasites
- Scientific study on the production performance of the existing livestock breeds

Livestock development proposals:

- Creating awareness and providing trainings on conserving and improving quality of locally available animal feed
- Livestock production problems could be minimized with application of improved breed, regular vaccination and medication service.
- Skill and knowledge gap filling in all livestock activities

3.3.8. **Natural resource management**

3.3.8.1. Common property resource and their management

The communal resources of the districts are forest land, economically important trees (*Boswelliaa*, *Acacia senegal*), communal grazing land, perennial rivers, different types of wild animals and fish and endemic birds. Common properties are always exposed to unwise utilization and management compared to private owned properties, because there are no strong bylaws that need to be followed up and enfored. And there is improper plantation, lack of proper management, deforestation of forests, weak policy implementation regarding illegal failing of trees and no clear guidance in sharing of the forest products and lack of participation of the communities starting from planning to prioritizing, identifying problems and solutions

Most of the cultivated lands of the study area in the mid land are set in up and down topography which is exposed to soil erosion and degradation that makes difficult for stabilization of soil and water conservation structures during high rain fall seasons. Most of the major soil and water conservation practices practiced in the study zone are physical SWC**: s**tone bund, deep trench, normal trench, stone check dam, gabion check dam, half moon**,** eye brow basin**,** and the Biological SWC: awir, local grass and elephant grass

3.3.8.2. Natural resource management constraints and challenges

- Weak policy implementation against irregular natural resource exploitation activities (e.g. hunters, tree cutters and illegal mineral mining)

- Lack of proper design in soil and water conservation structures
- Misuse of common properties
- Lack of integrated chemical and organic fertilizer use
- No clear guidance in utilization of forests and forest products, lack of community participation in planning, prioritizing and implementations of rules and regulations.
- Lack of awareness on sense of ownership in common properties.

3.3.8.3. Natural resource and production interrelationships

According to the farmers' discussion, free grazing and agricultural expansion have a significant influence on natural resource conservation and management. Agro-forestry practice in the districts is not common hence there is no any introduced agro-forestry tree species in the farm land. Recently**, a**cidity problem is observed in Tsegedie district. Though liming is recommended, all farmers are not still using

3.3.8.4. Prioritized and screened natural resources management problems

Problems associated with natural resources management in the districts are:

- Tree cutting in order to prepare land for cultivation
- Low survival of forest seedling

3.3.8.5. Natural resource Management policy recommendations

Natural resources management research proposals:

- Generating of effective mechanism of endangered economical tree species regeneration
- Identification and documentation of the potential natural resources
- Natural resource management developmental proposals
- Awareness creation on integrated land management
- Top down approach for physical soil and water conservation measures

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5. APPENDIX

Appendix Table 1. Livestock production and productivity of Endamehoni district

Livestock type	Population (head count)		Total	Proportion (%)		Milk (li/day)		Butter (Kg/week)		Number egg/month	
	Local	Improved		Local	Improved	Local	Improved	Local	Improved	Local	Improved
Cattle	76851	1070	77921	98.6	1.4	2	10.5	1	1.5	-	-
Sheep	77983	17	78000	100.0	0.0						
Goat	35074	-		100.0	0.0						
Poultry	86582	23911	110493	78.4	21.6					12	27
Camel	35	-		100.0	0.0						
Mule	513	-		100.0	0.0						
Donkey	13051	-		100.0	0.0						
House	305	-		100.0	0.0						
Total			335391								

Appendix Table 2. Livestock production and productivity of Raya-Alamata district.

Livestock type	Population (head count)		Total	Proportion (%)		Milk (li/day)		Butter (Kg/week)		Number egg/month	
	Local	Improved		Local	Improved	Local	Improved	Local	Improved	Local	Improved
Cattle	95072	1289	96361	98.7	1.3	3	12	1.5	1	-	-
Shoats	88450	30	88480	100.0	0.0						
Poultry	112000	4600	116600	96.1	3.9					12	24
Equine	5831	-	5831	98.7	1.3						
Total			307272								

Appendix Table 3. Livestock production and productivity of Raya-Azebo district.

Livestock type	Population (head count)		Total	Proportion (%)		Milk (lt/day)		Butter (Kg/week)		Number egg/month	
	Local	Improved		Local	Improved	Local	Improved	Local	Improved	Local	Improved
Cattle	95484	4750	100234	95.3	4.7	3	14	1	0.5		
Goat	61835		61835	100.0	0.0						
Sheep	48146		48146	100.0	0.0						
Camel	14950		14950	100.0	0.0						
Equine	8000		8000	100.0	0.0						
Poultry	90000	65000	155000	58.1	41.9					10	28
Total			388165								

Appendix Table 4. Major rain fed crop productivity and farmers perception of Raya-Azebo.

Major crops	Name of varaties		Av. Prod. Qt/ha		Level of perception	
	Local	Improved	Local	Improved	Local	Improved
Teff	Teff white	X-37	13	12	high	Medium
	Bine	Kuncho	13	18	medium	High
	Teff red	-	16	-	medium	-
	Magna	-	12	-	high	-
Sorghum	Aba Ere	-	28	-	High	High
	Dingle	-	26	-	high	-
	Kodem	-	25	-	high	-
	Red sorghum	-	40	-	Medium	-
	Jagrte	-	16	-	medium	-
Maize	Fetno	Melkasa 2	24	48	medium	High
	Emawayish	Melkasa 4	20	48	medium	High
	Amarica	Mamusha	12	24	medium	Medium
Barley	Sesa (two row)	-	18	-	medium	-
Wheat	Wheat (white)	Dashin	8	16		
	Gande	-	16	-		

Appendix Table 5. Major rain fed crop productivity and farmers perception of Endamehoni district.

Major crops		Name of varaties		Av. Prod. Qt/ha		Level of perception	
		Improved	Local	Improved	Local	Improved	Improved
1	Wheat	Wefche	Peaca flour	20	32	High	Medium
			Danfe		30		High
			Digelu		34		High
			Dinknesh		20		Medium
			Dashen		32		Medium
2	Barley	Saese'a		28	-	Medium	
		Zibna	-	32	-	High	
		Abiy'ekli	-	39	-	Medium	
		Purple barley		24	-	High	
		Haftu- sene		32	-	Medium	
		Gidme		40	-	Medium	
		Atena		32	-	High	
		Keyih shewa		32	-	High	
3	Tef	Bine	X-37	18	20	Low	High
		Magna	-	16	-	Medium	
		Keyih taf	-	24	-	Medium	
4	Field pea	Gotate	improved	20	29	High	Medium
5	Fababean	Ater	Improved	22	28	Medium	High
7	Lentil	local		11	-	High	

Appendix Table 6. Major rain fed crop productivity and farmers perception of Oflla district.

Major crops	Varieties		Av. Prod. Qt/ha		Level of perception	
	Local	Improved	Local	Improved	Local	Improved
Wheat	Purple wheat	Danfe	19	28	High	Medium
	Tamo'dane	Digelu	14	40	Medium	Medium
		Hidase	-	33	-	Medium
		Mekele 3	-	24	-	Medium
		Mekele 4	-	40	-	High
		Peaca flour	-	34		Medium
		Dashen	-	20		Medium
Barley	Purple barley		20	-	Medium	-
	Six row barley	-	28	-	Low	-
	Saesiea	-	24	-	Medium	-
	Zibna	-	20	-	medium	-
	Atena six row (hangale)	-	36	-	High	-
Sorghum (lequa)	Zengeda	-	40	-	High	-
Maize	Fetino	Global	40	50	Medium	High
Field pea	Gotate	Unknown	12	16	Low	Low
Lentil	Uknown		8		Low	

Appendix Table 7. Major rain fed crop productivity and farmers perception of Raya-Alamata .t

Major crops	Variety name		Productivity qt/ha	
	Local	Improved	Local	Improved
Sorghum	Degalit (Abola)	Gobye	55	20
	Gededom	-	40	-
	Kodem	-	44	-
	Abauare	-	56	-
	jigurte (early matured)	-	40	-
	Kayih Mashila	-	66	-
	Dangile (nech mashila	-	66	-
Teff	bune (early mature)	-	10.6	-
	Magna(late matured)	sukar Magna	13	14
		X-37	-	15
		Kuncho	-	10
Maize	Fetno (white)	Cross	45	20
	Emawayish (white)	Kuch biye	52	20
	Amarica (yellow)	-	32	

Appendix Table 8. Major irrigated crop productivity and farmers perception of highland areas at Endamehoni district

Major crops	Name of varieties		Av. Prod. Qt/ha		Level of perception	
	Local	Improved	Local	Improved	Local	Improved
Chickpea	Desi	-	24	-	High	-
Potato	Pale flower	Gudena	200	400	High	Medium
	White flower	Belete	120	400	Medium	High
		Gera		300		Medium
		Jelani		300		Medium
Pea	Gotate	White	16	40	Medium	Medium
Sasula	Unknown	-	400	-	High	-
Maize	Amarica	Hybrid BH545	18	24	Medium	High
	Berihun	Melksa -4	40	46	High	High
	Kinfi ‘asa		40		High	-
Garlic	Unknown	-	20		High	-
Tomato	-	Unknown	-	280		Medium
Carrot		Unknown	-	450	-	Medium

Appendix Table 9. Major crops grown at irrigation and their description at ofla district.

Major crops	Name of varieties		Av. Prod. Qt/ha		Level of perception	
	Local	Improved	Local	Improved	Local	Improved
Cabbage	-	Unknown	-	100	-	High
	-	Unknown	-	160	-	High
beet root	-	Round shape	-	100	-	High
	-	Oval shape	-	60	-	Low
Potato	Brown	Belete	50	80	Medium	High
	Unknown	Jelani	100	100	Medium	Medium
Maize	Emawayish	Global	16	50	Medium	Medium
	Fetno	Unknown	30	35	Medium	Medium
Pepper	Bora variety	-	80	-	High	-
Garlic	Unknown		50		Medium	

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