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Characterization and Analysis of Crop production System for Research and Development Intervention

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ABSTRACT

Agriculture is the dominant economic activity and the base of livelihood for the residents of East Hararghe Zone of Oromia Region, Ethiopia. The livelihood of the residents of East Hararghe Zone dependent on agriculture; however, the sector in the Zone is at subsistence level and efforts has been put to adapt and promote improved technologies that would help to boost production is not satisfactory. For the successful research and development intervention, analysis of the existing crop production system is crucial to understand the real situation. In this line, this study was with specific objectives of identifying crop production systems, and prioritizing major constraints in the study area. The study was used Participatory Rural Appraisals (PRA) tools such as household survey, focus group discussions, pair-wise ranking, and field observation. A total of 329 farm householders were selected using multi-stage sampling techniques. The collected data were analyzed using descriptive statistics. The result of PRA indicates that five major farming typologies:-Chat/Maize highland mixed farming system (CMHMFS), Sorghum/maize/cash crops midland mixed farming system (SMCMMFS), Coffee/maize mixed farming system (CMMFS), Sorghum/groundnut lowland mixed farming system (SGLMFS) and Agro pastoral/pastoral farming system (APPFS) were identified in the Zone. Results of PRA study revealed that the main crop production constraints were lack of improved varieties, shortage were identified as the first limiting factor followed by insect pests, shortage of improved seeds supply, erratic rainfall distribution, soil fertility declining and extension service availability in decreasing order of priority. Hence, there is need for research, development and institutional interventions to alleviate the identified constraints to crop production in the study area through holistic approach.

Keywords: Characterization; analysis, Crop production system; Constraints, opportunities, East Hararghe

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INTRODUCTION

Agriculture in Ethiopia is still playing a dominant role in the economy by its contribution, providing an employment for of the nation's labor force. The country is heavily dependent on agriculture as a main source of employment, income and food security for the majority of the population (IFDC, 2012). The sector is the economic mainstay of the overwhelming majority of Ethiopian people and will continue to remain so in the future (Assefa, *et al,* 2019). It contributes 36.2% of the country's gross domestic product (GDP) and 72.7% of employment and 70 percent of export earnings, and over 85% of the population deriving their livelihoods directly from agriculture (Getachew, *et al*., 2018). Thus, the sector remains the best opportunity for poverty alleviation, food security, and fuelling economic growth of the country.

Similarly, agriculture is the dominant economic activity and primary source of livelihood for Eastern part of Ethiopia in general and Eastern Hararghe Zone in particular. The Eastern Hararghe Zone is generally known for its cash and food crop production (Ralph, K. 2004; Zenebe, W., and Etana, E. 2002). In East Hararghe Zone, the farmers are conducting agricultural production in general and crop production in particular in different agro-climatic conditions. The agricultural activities also constitutes complex production activities involving growing a diversity of crops, and livestock production in order to meet the multiple needs of the households, and it is also mostly based on rainfall, and substance in nature. Even though the farmers are growing a diversity of crops, and their productivity is determined by multiple factors such as reliance on traditional farming techniques, soil degradation, population growth, drought, limited institutional supports and lack of improved technologies (Devereux, 2000; Arega, 2003; Chilot, 2007), and as a result about thirty-six percent of Ethiopian farming households are engaged in subsistence farming, living on less than two USD per day (MoA & ATA, 2014). Hence, achieving food security is still a major challenge for the areas. Therefore, improving the agricultural productivity in the country is not a matter of choice. To response the challenges, the farmers will be forced to change cropping systems, and resource use pattern. Hence, understanding of the change in crop production system through conducting analysis of farming system research is a prerequisite, and that is why the characterization and analysis of crop production system in Eastern Hararghe Zone was initiated and conducted.

Farming systems research is an approach for generating appropriate technologies for studying existing farming systems. It involves understanding of the existing farming systems in specific geographical areas, understanding of production practices and constraints at local conditions, understanding how a system works implies knowing the parts and how they relate to each other and to the environment, and guiding to generate best fit innovations to local conditions (Dillon, Plucknet and Vallaeys, 1978). Farming system is defined as a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate (FAO, 2007, NRI.org, 2004). Hence, it is required to prioritize agricultural production constraints to ensure sustainability of the sector in a given area.

East Hararghe Zone is well known for their climatic rainfall distribution and resulted frequent agricultural production failures. The farmers operate in different agro-climatic zones and under different socio-economic conditions, and are confronted with multiple constraints such as social and economic problems, changes in their environments from increased frequency of drought, rainfall variability, and occurrence of disease, land use change and natural resource degradation (Zigale, 2016 ; Zenebe, *et al,* 2015).

In order to response constraints and improve the productivity, Oromiya Agricultural Research Institute has gone a long way to establish research center (Fadis Agricultural Research Center) in the area However, information on agricultural production systems, constraints, and priority areas is very limited. To materialize the Oromiya Agricultural Research Institute in general, Fadis Agricultural Research Center in particular, it is very important to characterize and analyze farming system of the area. In this line, characterization and analysis of crop production systems was conducted with the overall objective of characterize and analyze the existing crop production systems of the area.

Objectives

The specific objectives includes:-

- To assess and identify the crop production systems of the area,
- To identify and prioritize crop production systems' constraints and opportunities, and
- To identify and prioritize research and development interventions for the study area.

METHODOLOGY

Description of the study area

The study was conducted in East Hararghe zone of the Oromia regional state of Ethiopia. The East Hararghe zone has a land area of about 24,900 square kilometers. From the total area of the zone, forest & wood land the highest share about (34.16%) followed by degraded land (28.33 %), and cultivated land (22.9%). The total area of the Zone is about 24,392.91 km2. The Zone has different agro-ecologies namely high land, midland and lowland. In the Zone, the lowland agro-ecology (60.32%) took more coverage followed by midland (32.24%) and highlands (7.44%) agro-ecologies and its altitude ranges from 500 to 3405 meter above sea level. The Zone was received 400mm -1010 mm annual rain fall, and the temperature also ranges between 14 to 25^{o}c (EHZ FEDO, 2018). Based on the 2007 census, the total population of the zone projected to 3.49 million in the year 2017. Agriculture is base of livelihood of the residents of the zone. It is characterized with smallholders farming system that involves crop-livestock mixed farming (EHZFECO, 2018).

Sampling Procedures and Sampling

Multi-stage sampling procedure was used to select representative districts, kebeles and sample households in the Zone. Based on agroecology, leading economic activities and major livelihood sources, the zone was stratified into five major sub farming systems; namely Chat Maize/Sorghum highland mixed farming (CMHMFS), Sorghum/Maize cash crops midland mixed farming system (SMCMMFS), Coffee/Maize mixed farming system (CMMFS), Sorghum-Groundnut lowland mixed farming (SGLMFS) and Agro pastoral and Pastoral farming system (APPFS). From each farm typology, representative districts and kebeles were selected by using systematic randomly sampling. Finally, a total of 329 farm households were randomly selected for primary data collection. In addition, farm household groups having 20 to 25 members were selected and established for group discussions using systematic sampling procedure, and atotal of 26 groups were established to collect primary data using group discussions.

Method of data collection

Participatory rural appraisal (PRA) tools were used to collect primary and secondary data from different sources. **Reviewing secondary data:** Secondary data were collected from different sources such as agricultural and natural resource development offices, irrigation offices at different levels, different NGOs and stakeholders working in the areas, CSA reports, and different un published reports. **Semi-structured interviews:** primary data were collected from farm households using semi-

structured questioners. The farm householders were interviewed on socio-economic and demographic characteristics, major crops produced; area allocated input use, constraints of crop, livestock production, natural resources management, and marketing problems. **Focus group discussion (FGDs):** a total 26 FGDs were conducted to collect primary data from groups and key informants.

Method of data analysis

Quantitative data were analyzed using descriptive statistics like mean, standard deviations frequency, percentage, chi-square and t-test using Statistical Package for Social Sciences (SPSS) version 20 for analysis. Qualitative data were analyzed using Participatory Rural Appraisal (PRA) tools such as pair wise ranking and qualitative manner.

RESULTS AND DISCUSSION

Classification/Identification of farming system typologies in the Study Area

The farming system of the East Hararghe Zone was broadly classified into five major farming system typologies based on agro-ecological and climatic conditions/factors and dominant pattern of farm activities and household livelihoods. The major farming system typologies of the EHZ:

- Chat/Maize highland mixed farming system (CMHMFS)
- Sorghum/maize/cash crops midland mixed farming system (SMCMMFS)
- Coffee/maize mixed farming system (CMMFS)
- Sorghum/groundnut lowland mixed farming system (SGLMFS)
- Agro pastoral/pastoral farming system (APPFS)

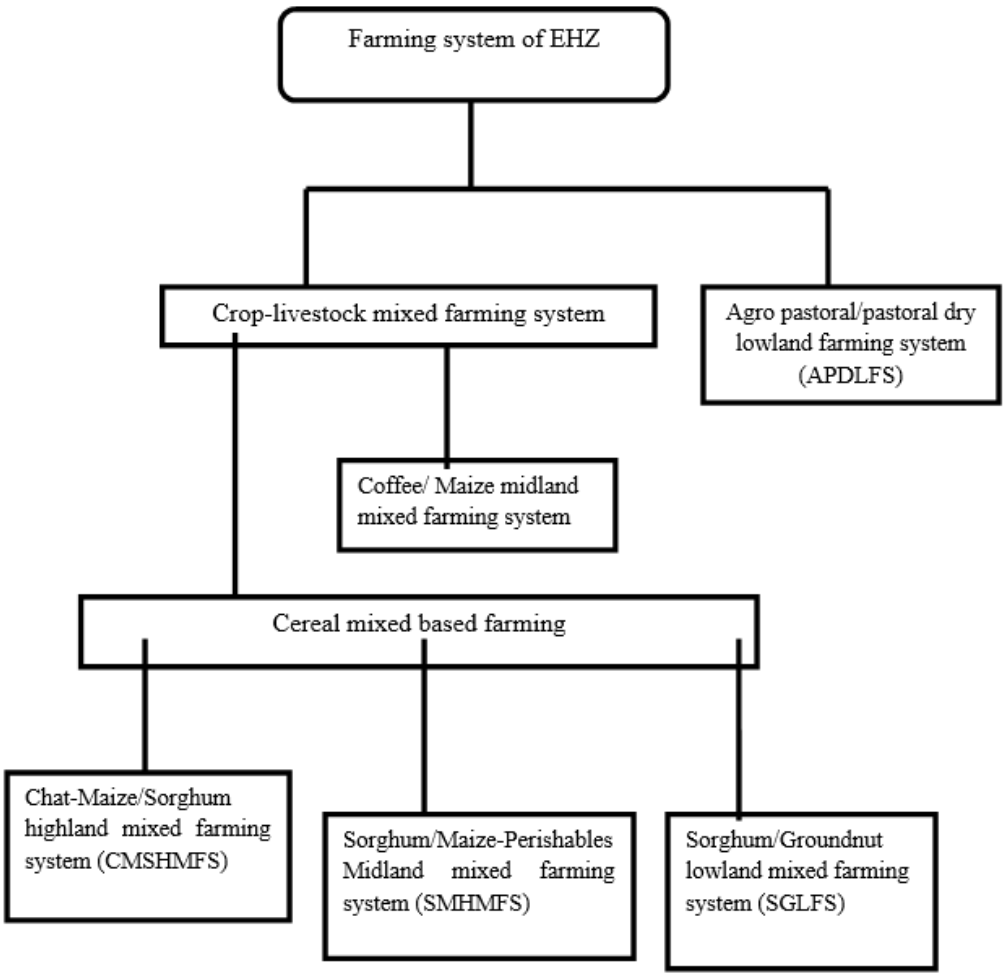

Table 1. Summary of description of the farming typologies of East Hararghe Zone

Main characteristics	Farming system typologies				
	CHMSHMFS	SMPMMFS	CMMMFS	SGLMFS	APPFS
Locations	Western and central	North western and central	Western, North western and central		Southeastern and Northern part
Districts delineated to the identified farming typologies	Dadar, Badano, Meta, Melkabalo, Goromuxi, Gurawa, Haramaya, and Kombolcha	Kersa, Goro Gutu, Haramaya,KombolchaJarso , Meta, M/ Balo K/ Chale	Bedano, Deder, MelkaBalo, Gurawa, Meta, K/Chale	Babile, Fadis, Gursum M/Balo	G/ Oda, Mayu, Midaga, Kumbi and Chinaksen
Area Km^2 (% of Zone)	1957.3(7.67%)	2359.79 (8.97%)	1512.79(6.4%)	7243(27.53%)	11,320(46.41%)
Population (% of Zone)	29.74%	28.46%	16.20%	13.20%	12.43%
Average rainfall(mm)	1200-2000	600 -1000	600 -1000	410- 820	200-820
Altitude (m.a.s.l)	2300-3200	1600-2200	1600-2000	900 -1500	500 -1700
Main source of livelihoods	Chat/maize/sorghum	Sorghum/cash crops/cattle	Coffee/maize/cattle	Sorghum/groundnut/ cattle	Cattle and goats/sorghum

Source: survey result, 2018

Socioeconomic characteristics of the respondents by farm typologies

The result indicates that out of the total sample households, about 93.35% were male-headed household farmers and the remaining were for female headed households (Table 2).From the result, the participation of female farmers in agricultural production and decision making is low in all farming systems of the study area. The mean age of the overall sample households heads was 40.58 years and statistically not significant among farm typologies(Table 2). The mean schooling years of the total sample households was 3.54 years of schooling with a statistically significant mean difference among the farming types at 1% probability level. The household heads from chat-maize/sorghum mixed highland, sorghum/maize midland mixed and coffee/maize based mixed farming systems have relatively better level of education than sorghum-groundnut lowland mixed and agro pastoral and pastoral farming systems of the study area (Table 2).

The average land holding of the overall sample household heads was 0.65 hectare which varies across farming typologies. The average land holding of chat-maize/sorghum mixed highland, sorghum/maize-perishables mixed midland, coffee/maize based mixed farming, sorghum-groundnut lowland mixed and agro pastoral households has found to be 0.39, 0.46, 0.36, 0.74 and 0.96 hectare, respectively with statistically significant mean difference at 1% probability level (Table 2). The result indicates that the farmers in lowland and agro pastoral areas possess relatively larger land holdings than farmers in the chat/maize highland mixed farming. As a consequence of growing population farm land holding is small in midlands and highlands of the study areas.

The survey result indicates that the mean family size of the total sample households was 6.48 persons in the area. Chat-Maize/Sorghum highland, sorghum/maize-Cash/Perishables Midland and Coffee/Maize based Mixed Farming Systemsfarm households have relatively larger family sizes than Cereal/Sorghum-Groundnut lowland mixed and agro pastoral households with mean difference being statistically significant at 5% significance level (Table 2). Regarding family labor force in ME, it was found that there are on average, the total labor force was 2.32 ME. The result indicates that there are relatively larger number of labor force for Chat-Maize/Sorghum highland mixed farming system (CMHMFS), Sorghum/Maize-Cash crops midland mixed farming system (SMCMMFS) and Coffee/Maize mixed farming system (CMMFS) areas than Sorghum/groundnut lowland mixed and agro pastoral areas, with statistically significant among

the farm types at 1% level of significance. In the Sorghum-Groundnut lowland mixed farming system, and Agro Pastoral/Pastoral farming system areas, during FGDs the participant farmers noted that young people are migrating to the neighboring districts.

The survey result indicates that on average, the total sample households own 3.44 units of livestock in terms of tropical livestock unit (Table 2). The households of sorghum/groundnut lowland mixed and agro pastoral areas owned relatively larger number of livestock unit than chat/maize highland, sorghum/maize midland mixed, and coffee /maize based farming areas, with statistically significant among the farming at 1%level of significance. This mainly due to limited availability of feed resources such as limiting the availability of grazing land, and the available land is mainly utilized for crop production in highland and midland farming areas. Farm households in the study areas earn cash income from sales of crops, livestock and their products, and off/non-farm employment opportunities. The survey results show that the total household annual income from all sources was 20,590 birr with difference being statistically significant at 5% level (Table 2). On average, higher annual income was observed in sorghum/maize-perishable crops midland mixed farming (25,070 birr per year), followed by 21274 and 15450 birr per year for coffee/maize midland and chat/maize highland mixed farming systems, respectively.

Table 2. Socioeconomic characteristics sample respondents by farming typologies

Variables	Farming system typologies					
	CMHMFS (n=82)	SMCMMFS n=78)	CMMFS (45)	SGLMFS (N=64)	APPFS (n=60)	Overall (n=329)
Sex of HH (male head)	95.27	91.84	86.49	89.70	94.31	93.35
Age of HH head (years)	42.78(8.61)	38.7(9.45)	40.7(9.14)	40.47(10)	40.60(8.12)	40.58(9.23)
Education level	3.92(3.29)	4.72(3.62)	4.6(3.52)	2.38 (3.16)	2.03(3.07)	2.54(3.17)**
Land holding (ha)	0.39(0.21)	0.46(0.29)	0.36(0.39)	0.74 (0.48)	0.96(0.77)	0.65(0.53)*
Family size	7.35(2.91)	7.05(2.99)	6.05(2.69)	5.78 (1.88)	5.24(1.96)	6.48 (2.27)*
Labor force (ME)	1.67(0.89)	1.81(0.77)	1.72(1.36)	2.86(1.14)	1.32(1.27)	2.28(1.17)*
Livestock holding(TLU)	2.27 (2.16)	2.31(3.64)	2.20(2.46)	3.64 (5.46)	4.56 (0.84)	3.44 (5.46)**
Farming experience	21.64(9.52)	20.37(9.17)	21.34(9.37)	20.47(8.7)	17.44(6.46)	21.48(8.56)**
Annual income (Birr, 000)	5.45(11.60)	25.64(22.81)	21.274(32)	12.52 8.2)	10.63 (7.6)	20.58(18.4)**

Source: survey result, 2018 Note: *= significant at 1%, **=significant at 5%,

Access to institutional support system

The household survey result indicates that larger proportions of the total households had accessed extension services in groups or individually with difference in frequency of contact. Out of the total households, about 82.25% had accessed to extension services (Table 3). The farming system for access to extension services shows that relatively low percentage of access to extension services were reported in agro pastoral and pastoral farming system. The average frequency of extension contact in number was 44 per year. The FGD farmers also reported as the major gap in access to extension services include delivering limited services and limited/lack of conducting knowledge transfer through training and pre-extension demonstration at FTCs. The result further indicated that out of total respondents,

about 20.69% of respondents participated on FTC based training and demonstration in the study areas (Table 3).The average walking distances from farmers' residences to the farmers training center (FTC) was found to be 1.78 km in the study area. With regard to memberships to cooperative, about 57.83 % of the total respondents were members of the farmers' cooperatives in the study area. On average the respondents traveled 10.17 km to sell their products to the nearest market center (Table 3).

The higher number of memberships was observed in coffee-maize based midland mixed farming followed by chat-maize highland mixed farming where as relatively low membership was observed in agro pastoral and pastoral farming systems. The FGDs participant farmers were discouraged about membership of farmers cooperatives. They pointed out that the cooperatives are established for providing input and output marketing services to members of the community. The survey result indicates that from the total respondents, on average, about 91.73% of respondents did not use credit services available in their area. The result of the study further indicates that from the total respondents, on average about 53.09% of respondents obtained market information from different sources in the areas (Table 3).

Table 3. Sample respondents access to institutional support by farming typologies

Description	Farming system typologies					
	CMSH (n=82)	SMCM (n=78)	CMMM (45)	SGLMF (N=64)	APPFS (n=60)	Overall (n=329)
Access to extension services(%, yes)	79.66	91.89	90.46	90.28	65.71	82.25**
Frequency of extension contact	52	55	51	43	28	44*
Cooperative membership (%, yes)	65.31	64.20	84.50	58	43.79	57.83**
Access to credit services(%, no)	93.59	87.62	85.60	90	95.7	91.73
FTC based demonstration(%, yes)	25.80	21.20	20.65	23.20	15.13	20.69**
Access to market information (%)	46.49	55.84	45.80	62.92	47.10	53.09**
Distance to nearest market (km)	8.31	6.73	9.74	5.80	18.95	10.17*
Distance to FTC(km)	1.73.	2.26	2.36	1.96	3.25	1.78**

Source: Survey result, 2018

Major crops cultivated and cropping systems by farming typologies

In Chat-Maize/Sorghum highland mixed farming system (CMHMFS), crop production is an important livelihood activity for the farmers and is mainly based on rain-fed agriculture. The area is characterized by intensive cropping system such as intercropping (annual crops with perennial, annual with annual crop) and relay cropping system. The major crop types grown in this farming typology are maize, sorghum, wheat, barley and teff from cereal crops. Haricot bean, faba bean and field peas are among pulse crops grown in the area. Horticultural crops like potato, garlic, sweet potato and apple are grown in this farming system in this area. Maize, sorghum, wheat and barley are grown largely to satisfy the food consumption needs of the families whereas potato, garlic, coffee and chat are commonly grown for sale to generate cash income for the family in the area.

he survey result showed that the average area of land allocated by the farm households for major crops and it revealed that Chat has a lion share

followed by maize and sorghum in this farming system. According to the survey results, on average, about 20.30% of the total area under maize production followed by sorghum, barley and wheat during the 2017 production year in this farming system. From pulse crops, faba bean is the most favorable in this farming typology and it accounts for about 5.25% of the total land followed by haricot bean covering about 3.38% of total land. The average area of land allocated for potato, coffee, and chat production was reported to be about 10.15%, 3.38% and 23.69% respectively in this farming system (Table 4).

In Sorghum/Maize midland mixed farming system (SMCMMFS), the major cereal crops produced in this area, sorghum, maize and wheat as food crops. In addition to food crops, the farmers also grow cash crops such as vegetables (potato, cabbage, onion, lettuce, carrot, garlic, tomato, sweet potato, and beet root), and pulse crops such as haricot bean, faba bean and lentils, and linseed from oilseeds are produced and Khat are important and permanent cash crops grown in the area. The production of sorghum, maize, wheat, teff, potato, onion, coffee and Khat is heavily dependent on rainfall while the horticultural crops are mainly produced using rain fed and irrigation in the area. Survey result shows that sorghum (0.14 ha) has a lion share followed by potato, maize and Chat in this farming system (Table 4).

In Coffee/Maize Mixed Farming System (CMMFS), coffee is the main crop grown in this area followed by Chat, maize, sorghum and wheat. In addition, haricot bean, potato, cabbage is also grown in the area. Coffee and Chat are the predominant cash crops in the area. The survey result indicates that the average area of land allocated for coffee was 0.13 ha (Table 4). Cropping systems practiced in this area are sole, mixed, intercropping, and double and relay cropping systems. The area has a bi-modal rainfall pattern and, as a result, some farmers practice double cropping where barley/potato is grown following the rainfall flash in the spring and then wheat/Faba bean is grown during the main season. Few farmers also practice relay planting of pulse (chickpea) and spice (fenugreek) under maize in this area.

In Sorghum/maize-groundnut lowland mixed farming system (SGLMFS), crop production is the major livelihood option for this area. The major cereal crops that are produced in the area are maize and sorghum. In addition to cereal crops produced, pulse and oil crops such as haricot bean, ground nut and sesame are produced. Regarding fruits and vegetables, onion, tomato, chili pepper, papaya and mango are the major ones that are grown in the area. In limited areas where have irrigation water, the farmers produce maize using rainfall during main season, and after harvesting of maize, they grow tomato, chili pepper and onion using irrigation during the dry season. According to the survey results, on average, 0.320 ha of land was allocated for sorghum followed by groundnut (0.24 ha) and maize (0.14 ha) in this farming system.

In Agro Pastoral and Pastoral Farming System (APPFS)**,** livestock keeping/rearing is the main livelihood sources of the agro pastoral communities followed by crop production. Pastoralists that were shifted agro pastoral and farmers settled from mid-highland areas are practiced crop production in the area. The agro-pastoralists are practicing crop production and major crops cultivated are sorghum and maize for household consumption, whereas, groundnut and haricot bean are produced both for household consumption and market. Mono cropping of sorghum, maize and is a common practice in the area. Intercropping of sorghum and maize with haricot bean and groundnut are also practiced in this area**.** The survey results, as presented in Table 4 indicated that the average area of land allocated for sorghum was 0.26 ha followed by groundnut (0.24ha), maize (0.20 ha) and haricot bean (0.13ha).

Table 4. Major crops cultivated and cropping system by farming typologies in the study areas

Type of crops	Farm typologies									
	CMHMFS		SMMMFS		CMMFS		SGLMFS		APPFS	
	Mean(ha	%	Mean(ha	%)	Mean(ha)	%	Mean(ha)	%	Mean(h	%
Sorghum	0.1	16.92	0.14	28.90	0.1	16.67	0.32	34.30	0.26	32.50
Maize	0.12	20.30	0.11	16.42	0.12	20.00	0.14	15.01	0.21	26.25
Wheat	0.031	5.25	0.06	8.96	0.04	6.67	0.013	1.39	0	0
Barley	0.04	6.77	0	0	0.01	2.67	0	0.00	0	0
Faba bean	0.03	5.08	0	0	0.02	3.33	0	0.00	0	0
Field Pea	0.01	1.69	0	0	0	0.00	0	0.00	0	0
H/bean	0.02	3.38	0.01	1.49	0.01	1.97	0.1	10.72	0.13	16.25
Ground nut	0	0	0	0	0	0.00	0.26	30.72	0.21	25.00
Potato	0.06	10.15	0.13	19.40	0.07	11.67	0	0.00	0	0
Cabbage	0.02	3.38	0.06	8.96	0	0.00	0	0.00	0	0
Onion	0	0	0.01	1.49	0	0.00	0.04	4.29	0	0
Tomato	0	0	0	0	0	0.00	0.02	2.14	0	0
Coffee	0.02	3.38	0.03	4.48	0.13	21.67	0	0.00	0	0
Chat	0.14	23.69	0.12	17.91	0.1	16.67	0.06	6.43	0	0

Sources: Computed from Survey result, 2018

Use of improved crop technologies

Use of improved seeds of crop varieties

The farmers obtain seeds of crops that they grown from different sources. For sorghum, maize, haricot bean and groundnut, own/recycled seeds, farmers and local market are common source. The survey result indicates that improved maize seed varieties such as BH-660, BH-661, BH 540 and BH-543 in highland mixed areas and BH-140, Pioneer (PHB-3253), PHB-30-G19 (Shone), BH543 and Awasa-511 in midland areas were accessed. In sorghum/groundnut lowland mixed and Agro pastoral areas, Melkasa serious such as Melkasa-2 and Melkasa-4 varieties are commonly cultivated in the areas. Regarding improved wheat variety, Kekeba, Pavon and Jafferson were cultivated in the area in lowland mixed farming areas whereas varieties such as HAR1685 (Kubsa), HAR710, Digalu, Dekeba, Dandea, Tuse and Hidase in highland and midland mixed farming area.

The survey result indicates that low use of improved variety was reported for sorghum and groundnut production, no area under cultivation using improved variety for sorghum in Chat /maize/sorghum highlands of mixed farming (CMHMFS) and CMMMFS. In SMCMMFS, SGLMFS, APPFS farming systems, only 6%, 20% and 11% of area under cultivation was resulted from the use of improved variety for this crop, respectively (Figure 1). Similarly, only 16.35% and 11% of area under cultivation was reported from the use of improved variety for groundnut in SGLMFS and APPFS respectively. This low level of use could be mainly due to unavailability of the improved varieties, supply shortage and/or the available technologies might have not reached the farmers adequately and timely. Relatively higher percentage of maize production was through the use of improved variety was reported in SMPMMFS (52%) followed by SGLMFS (40%)

farming systems while the lowest was reported in CMMMFS (32%) (Figure 1).

The survey result also indicates that on average out of total area of land under wheat production, relatively higher percentage of wheat production area was under the use of improved variety in SMPMMFS (50%) followed by CMSHMFS (47%) farming systems while the lowest was reported in SGLMFS (6%) and the rest was covered by local varieties. The survey result further indicates that area under improved seed of potato varieties, reported about 43.50% and 32% in SMPMMFS and CMSHMFS respectively. The largest area to which improved seeds used were under coffee estimated about 37.49% and 23.48% in CMMMFS and SMPMMFS respectively (Figure 1).

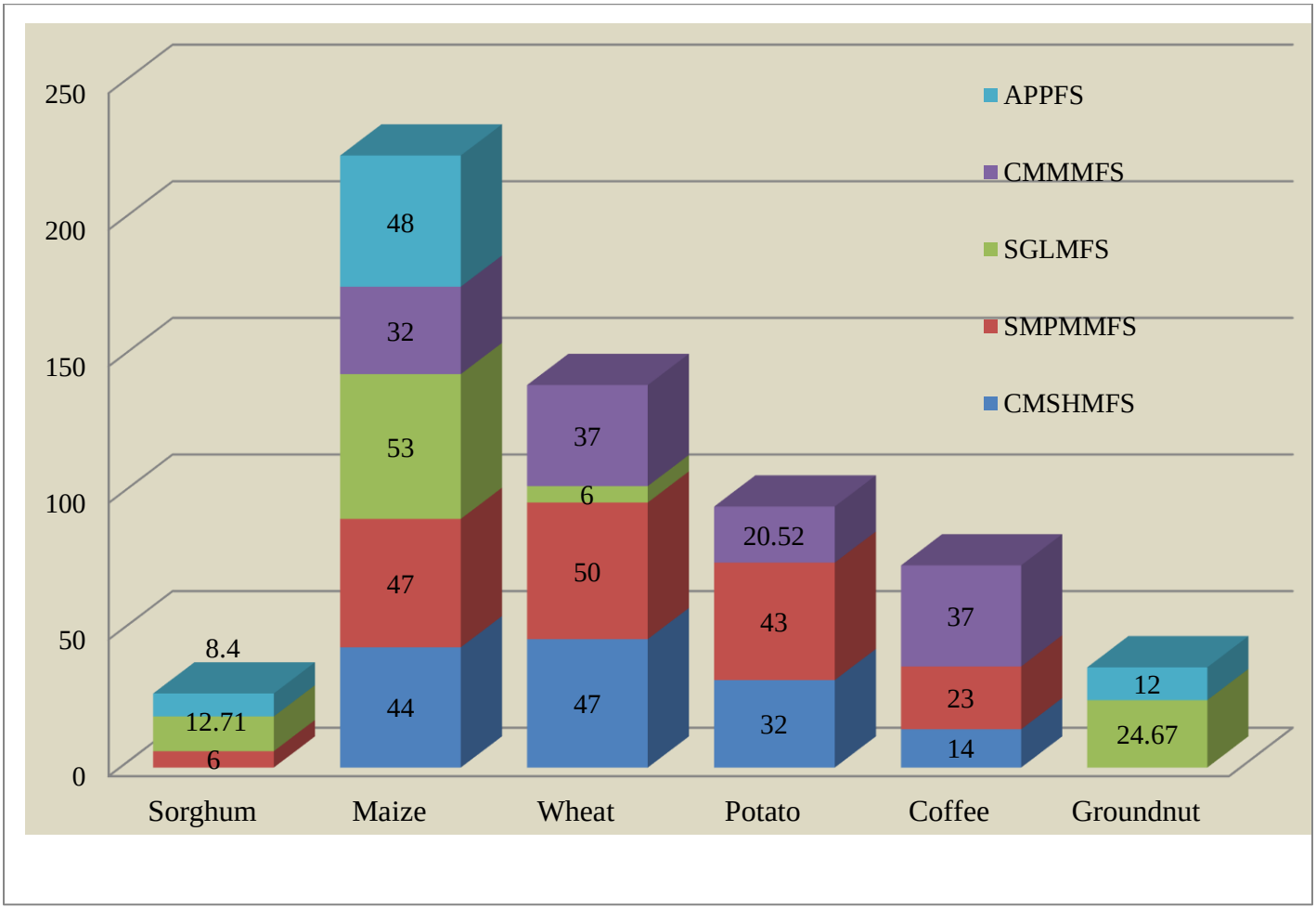

Figure 1, Use of improved seeds of crop varieties (%) in the study area

Generally, the result revealed that there was low level of use of improved varieties some crops. This could be mainly due to unavailability of the improved varieties, supply shortage and/or the available seeds might have not reached the farmers adequately and timely. This is main bottleneck for farmers and that forced farmers to depend on local varieties and for hybrid seed varieties that forced to maintain their lifespan as being improved variety. The farmers noted that there are lack improved varieties for most crops although there are limited supply improved varieties for maize, wheat, haricot bean, and vegetables and fruit crops**.** Besides of limited supply of improved seeds for limited crops, high price of seeds is also challenging the farmers to use improved seeds sustainably in the study areas.

Crop production and soil fertility management

Soil fertility depletion due to deforestation, soil erosion, lack of crop rotation, limited use of manure and lack of cereal-legume rotations, complete removal of crop residue leading toultimately resulting in low crop productivity in the area. However, the problem is more severe in highland and midland mixed farming areas where, crop production is undertake intensively. To address these problems, the farmers use different kinds of soil fertility management practices in all of the study areas. The inorganic fertilizers applied by farmers are NPS and Urea for maintaining soil fertility and improve crop productivity in the study areas. The PRA study indicate that the farmers use inorganic and organic fertilizers, conservation practices and cropping practices to maintain soil fertility in the study areas. The farmers mentioned that application of fertilizers at the rate and time of time of application is determined by availability of moisture. In SMPMMFS and CMSHMFS, on average about 45% and 40% respondents applied inorganic fertilizers to sorghum respectively (Figure 2). In CMSHMFS relatively the highest percentage of respondents, 89% of the respondents applied fertilizers to maize fields followed by SMPMMFS. In CMSHMFS, 76% of the wheat growers use fertilizers for wheat production (Figure 2). Regarding application of organic fertilizers, the farmers use manure to maintain soil fertility. According to FGD farmers in the highland and midland mixed farm types, the use manure common for all crops types but the rate of use increases for cash crops such as potato, cabbage, coffee and Khat fields. Likewise, in lowland mixed and agro pastoral areas, the farmers are applied to maize, sorghum and tomato. Manure application is also common in the area. Its preparation is performed dominantly by female while male are responsible for transporting to the field and its application.

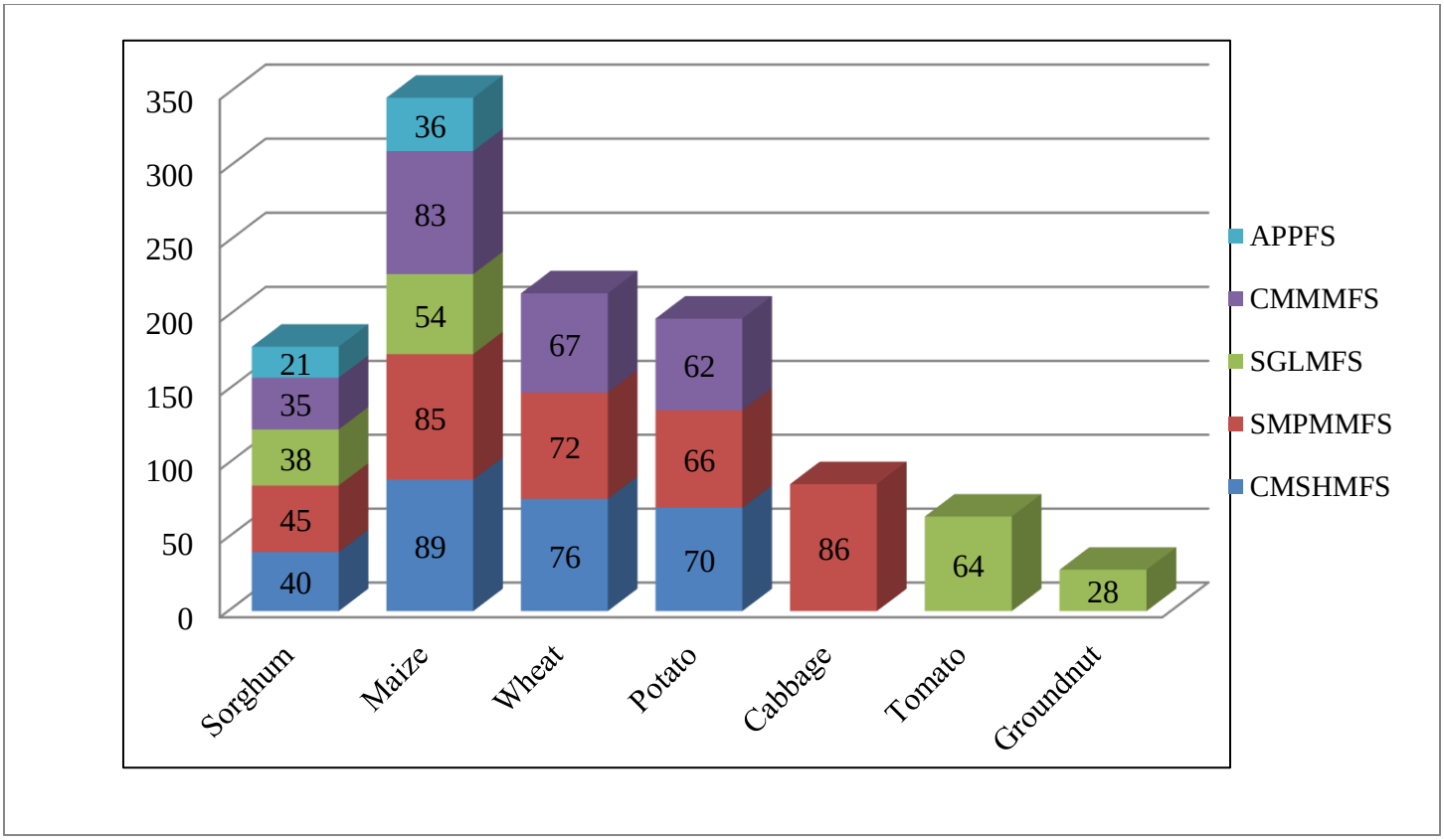

Figure 2. Inorganic fertilizer use by sample respondents (%) in the study area

The farmers reported that the rate of fertilizer application was low due to low rate of fertilizer application was high fertilizer price. Generally, the trend shows the supply of inorganic fertilizer is fluctuate; this may relate to different reasons such rainfall distribution and high cost. This result shows underutilization of these fertilizers which would in turn result in lower yield levels. Problems encountered by farmers in using fertilizer are high fertilizer price which is unaffordable for the poor, rainfall shortage and inadequacy especially in the low land areas, lack of awareness of some farmers on fertilizer application and unavailability at the right time and place. Agronomic practices

All farmers use oxen plowing for land preparation. The land is tilled 2-4 times until it gets ready for seed sowing depending on crop types, moisture and nature of land (Table 5). Major constraints of land preparation and planting as mentioned by the key informants are erratic nature of rainfall, shortage of farm implements and labor. The sources of power for farm operations are human labor and animal in the area. In highland and midland areas, due to practicing intensive cropping systems, human and animal powers are the main sources for farm operation but in some part of midlands, and lowland and agro pastoral areas, combination of animal and machineries powers used. Land preparations are done using hand hoe and oxen ploughs in highland and midland areas whereas in lowland areas, land preparations particularly primary and secondary tillage are conducted using tractor and the third one is by ox-plow. Broad casting and hand drilling is common planting of all crops due to lack of row planter for different crops in the study areas. Both broadcasting and row planting are practiced in the all of study area. Harvesting and threshing of major crops grown in all farm types are done using human labor and animal trampling is common. The FGD farmers' lack of access to row planter for major crops and harvest and postharvest technologies such as threshing machine for maize, sorghum and wheat are the main problems in the areas.

Table 5. Agronomic practices of major crops grown by farm typologies

Agronomic	Farm typologies				
	CMHMFS	SMCMMFS	CMMMFS	SGLMFS	APPFS
Power source	Human labor and draft animal	Human labor and draft animal	Human labor and draft animal	Tractor ,human labor and draft animals	Tractor ,human labor and draft animals
Method of plough	Hand hoe and oxen ploughing	Hand hoe and oxen ploughs	Hand hoe and oxen ploughs	Primary and secondary tillage using tractor	Primary and secondary tillage using tractor
Tillage frequency	2-3	2-3	2-3	3-4	3-4
Sowing method	Row planting for maize Broadcasting for wheat, barley and sorghum	Row planting for maize and wheat, Broadcasting for sorghum	Row planting for maize Broadcasting for wheat, barley and sorghum	Row for maize and ground nut Broad casting for sorghum	Broadcasting
Cropping system	Mono, inter/mixed and rotation cropping	Mono, inter/mixed and rotation cropping	Mono, inter/mixed and rotation cropping	Mono and inter/mixed cropping	Mono and inter/mixed cropping

Source: PRA survey report, 2018

Pest infestation and management practices

During PRA survey major crop disease and insect pests that affect the crop productivity such as weeds

Weeds infestation:-*striga, parthenium, Orobanche, Amaranthus, Cocklebur, Spotted spurge cyprus spp, lantnana camara* are the major weeds species that were prevalent in almost all farming systems.

Disease:-The major diseases reported by PRA farmers are *Curly top virus,* blight, bacterial wilt and *fruit decay/Tuta Absulata* on tomato, honeydew and head smut on sorghum and maize, rust on wheat, onion and potato,rot root on groundnut, *Fruit decay,* Powdery mildew, anthracnose on mango and avocado, bacterial wilt and white mold on banana,down mildew on onion, and late blight on potato, leaf blight and powder mildow on common bean, Frost on chat and potato, Moulds on chat, Coffee Berry Disease (CBD), die-back and leaf rust is causing severe damage and important yield reductions on coffee in coffee production potential farming. There is no resistant variety adapted to the agro-climatic conditions.

Insect Pests: Army worm, stalk borer and American Fall Army Worm were the most prevalent and caused damage to crops in the areas, Termite on maize in lowland areas, aphids on cabbage, sorghum, maize and haricot beans, grain weevils on different crops, rodents, bird and wild animals attack on sorghum. These pests attack crops at different growing stages such as at beginning of germination, vegetative stage, at flowering stage and grain filling stage of the crops. As a result crop production has low yields due to occurrence of these pests and lack of proper disease management practice.

Crop Production Constraints by farm typologies

During PRA study, the participant farmers and agro pastoralists were identified several constraints that limit crop production in the study area and ranked them by farm typologies (Table 6).Shortage of improved seeds supply, inappropriate crop management practice, lack of improved varieties, farm inputs (pesticides, fertilizers), insect pests and disease, weed infestation, cultivable land shortage and erratic rainfall distribution/drought are mentioned among others. Shortage of improved seeds supply was ranked fist in sorghum/maize/cash crops midland mixed farming system (SMCMMFS), Agro pastoral/pastoral farming system (APPFS) and second in Chat/Maize highland mixed farming system (CMHMFS) and Sorghum/groundnut lowland mixed farming system (SGLMFS) and third in Coffee/maize mixed farming system (CMMFS) by PRA farmers in the study area (Table 6). Supply shortage of improved varieties and poor quality (maize, sorghum, wheat).

The participants of the PRA strongly mentioned that shortage of improved seeds supply was the most important constraints to crop production in the study area. Supply shortage of improved varieties, and poor quality seed (ungraded, not clean, poor germination) and lack of seed sources for high-value crops such as vegetables and fruit. As a result farmers use local varieties which are low yield and susceptible to pests. The situation more severs for cash crops such as groundnut, tomato, onion, hot pepper and lack of grafted seedlings for fruit crops. The FGD farmers noted improved tomato, onion, and mango yields are low due to lack of/limited use of improved varieties of these crops. As a result farmers use local varieties which are susceptible to pests, and few farmers used improved varieties which were supplied by office of agriculture and NGOs. Generally, only a few farmers used improved seeds of cereals, oil crops, pulse vegetable and fruit crops, the majority of the farmers used local varieties in all farming systems.The result of FGD farmers and field observation indicates that inappropriate crop management practices such as improper time of planting, spacing, lack of use of recommended rate of inputs, improper plant density due to weak

extension services problems that affect crop production. It was ranked third in APPFS, fourth in CMMFS, fifth in CMHMFS and SGLMFS, and sixth in SMCMMFS in the area. The participants reported that weak extension service on use of improved crop technologies, and this related to existence of weak extension and farmers participation on improved technology demonstration were also noted as major problems of the farmers in the study area.

Lack of improved varieties was ranked fist in Chat/Maize highland mixed farming system (CMHMFS) and Sorghum/groundnut lowland mixed farming system (SGLMFS) and Agro pastoral/pastoral farming system (APPFS) whereas second in Sorghum/maize/cash crops midland mixed farming system (SMCMMFS)and Coffee/maize mixed farming system (CMMFS) by PRA farmers in the study area (Table 6).Lack improved varieties for most food and horticultural crops are a major limitation to increasing crop production in the study area. During PRA study, the participant farmers noted that lack of improved varieties for sorghum, barley, wheat, maize, pulse crops such as haricot bean, and oilseed crops such as groundnut, for fruit and vegetable crops, and coffee, was the major limiting factors in crop production in the study area.

Low utilization of agricultural/farm inputs was ranked third in SGLMFS and fourth in CMHMFS, SMCMMFS, CMMFS and APPFS by PRA farmers in the study area (Table 6).The PRA farmers reported that inadequate use of agricultural inputs such as seeds, fertilizers and pesticides due to unable to access nearby, not timely available and unaffordable (high price) as a major crop production constraint in the study area. This leads to inadequate use of fertilizers due to high price and moisture stress affect crop production in the study area.

Insect pests: -the PRA farmers were ranked second in CMHMFS, SGLMFS and CMMFS where as third in SMCMMFS and APPFS by the PRA farmers in the study areas (Table 6). The participant farmers listed and reported that insect pests such as stalk borer, cutworm, Army worm , Grain weevils on different crops, Rodents, bird and wild animals, Spider mite on potato, Aphids on cabbage,and Fruit fly on mango as the major constraints to crop production in the study area.

Crop disease:-the PRA participant farmers ranked second in SMCMMFS, third in CMHMFS, SMCMMFS, CMMFS and SGLMFS whereas ranked fifth in APPFS (Table 6). The major diseases reported by PRA farmers are *h*oneydew and head smut on sorghum and maize, *Curly top virus,* blight, bacterial wilt and *fruit decay/Tuta Absulata* on tomato, Powdery mildew, anthracnose on mango and avocado, Honeydew and head smut on sorghum and maize, Down mildew on onion, Late blight on potato, Frost on chat and potato, and Moulds on chat, and Coffee Berry Disease (CBD) and die-back on coffee causing severe damage important yield reductions on crop production in the identified farming systems.

The PRA participants noted that insect pests like stockbroker on maize and sorghum, cutworm on maize and wheat, and diseases like late blight and on potato, yellow and stripe rust on wheat, rust on garlic are serious factors affecting growth and production of the crops in the area. Pests and diseases are the most frequently stressed problems in the majority of the farming systems. Moreover, production of wheat and potato are also affected by rust and blight diseases, respectively.

Weed infestation was ranked second in SGLMFS andAPPFS as a bottleneck for crop production (Table 6).Among *weed, striga, parthenium, Amaranthus, Orobanche and lantnana camara* are the most common and major weeds species that were reported by the farmers in study areas.Cultivable land shortage was ranked first in CMSHMFS, SMCMMFS and CMMFS, third and fifth in SGLMFS and APPFS respectively (Table 9). Shortage of cultivable land is becoming more

and more severe in the face of an ever increasing population in the mid-highland areas and the land resource tends to fail to support the farming community need. The problem severs in midland and highland area due to high population with nature of the topography and lack of alternative employment opportunities. This leads to shrinking of individual landholdings.

Erratic rainfall distribution/drought was ranked first in SGLMFS and APPFS in constraining productivity of crops (Table 6). The farmers noted that for the last five to ten years- shortage and erratic distribution, Variability (start in late or early), affecting the regular farm activities such as land preparation, planting, cultivation and fertilizers application, causing under use inputs and resulting in crop failure and low production, and in recent years, crop production using early rainfall. According to farmers, rainfall shortage and variability was ranked first in constraining productivity of crops in the area. It should be understood that with risk factors high for climatic hazards and/or pest and diseases, the overall risk taking increases considerably with high production costs.

Table 6. Matrix scores and pair wise ranking for crop production constraintsby farm typologies

Major constraints	**Farm typologies**				
	CMHMFS	SMCMMFS	CMMFS	SGLMFS	APPFS
	Score(rank)	Score(rank)	Score(rank)	Score(rank)	Score(rank)
Shortage of improved seeds supply	7(2nd)	8(1st)	6(3th)	7(2nd)	8(1st)
Inappropriate crop management	4(5th)	4(6th)	5(4th)	4(5th)	6(3rd)
Lack of improved varieties	8(1st)	7(2nd)	7(2nd)	8(1st)	8(1nd)
Farm inputs (pesticides, fertilizers)	5(4rd)	5(4th)	5(4nd)	6(3rd)	5(4th)
Insect pests	7(2nd)	6(3rd)	7(2th)	7(2nd)	6(3rd)
Crop disease	6(3th)	7(2nd)	6(3rd)	6(3rd)	4(5th)
Weed infestation	3(6th)	3(6th)	1(8th)	7(2nd)	7(2nd)
Cultivable land shortage	8(1st)	8(1nd)	8(1st)	6(3th)	4(5th)
Erratic rainfall distribution	7(2rd)	6(3nd)	7(2nd)	8(1st)	8(1st)

Source: PRA survey result, 2019

Marketing related constraints by farm typologies

During PRA study, the participant farmers were identified and prioritized major marketing constraints existed in the identified (Table 7). The predominant marketing constraints are low price of agricultural products for cash crops (horticultural crops, coffee), high price of agricultural inputs such as improved seeds, fertilizers, herbicides, and lack of market access were server for farmers in areas far from roads

and the urban market, cash shortage for inputs due to poor of saving culture and the inadequate access to credit services, lack of market information due to institutional problems, lack of road facility, price fluctuations/low price for coffee product , payment problems which not paid for the producers when they need and high price of agricultural inputs.

Table 7. Matrix scores and pair wise ranking of crop marketing related constraints

Marketing constraints	Farm typologies				
	CMSHMF	SMPMMF	LCSMGS	CCSF	APPSF
	Score(rank	Score(ran	Score(ran	Score(ran	Score(ran
High price of inputs	4(2nd)	4(2nd)	5(1st)	3(3rd)	3(3rd)
Low prices for cash crops	5(1st)	5(1st)	4(2nd)	5(1st)	4(2nd)
Cash shortage for inputs	3(3rd)	3(3rd)	5(1st)	2(4th)	4(2nd)
Lack of market access	3(3rd)	2(4rth)	3(3rd)	4(2nd)	5(1st)
Lack of access to credit	1(5th)	1(5th)	2(4th))	1(5th)	1(5th)
Lack of market info.	2(4th)	1(5th)	1(5th)	2(4th)	2(4th)

Source: PRA survey result, 2019

Major constraints to natural resources

The FGD farmers in all of the study areas identified that deforestation, depletion of water resources, land shortage, erratic distribution of rainfall, depletion of soil fertility; soil erosion and flood were main constraints for the sustained crop production in the areas. The participants of the PRA discussion in each of the farming systems identified several challenges to natural resources and ranked them using pair-wise ranking (Tables 8). In highland mixed farming areas, deforestation and shortage of farm land holding were identified as the first limiting factor followed by depletion of water resources, rainfall variability/drought due to climate change, soil fertility depletion and soil erosion, declining of grazing land and flood as constraint to natural resources use in sustainable way (Table 8).

In the case of midland mixed farming system areas, depletion of water resources (ground water, irrigation) and erratic distribution of rainfall were identified to be the main problems followed by deforestation and shortage of farm land holding, soil fertility depletion as priority constraints to natural constraints. The result of PRA study further indicates that depletion of water resources/water shortage and drought were ranked in first in lowland mixed and agro pastoral areas followed by deforestation, grazing land shortage, soil fertility depletion and shortage of farm land hold were main constraints for using natural researches in sustainable way.

Table 8. Matrix scores and pair wise ranking natural resources related constraints

Major constraints	Farm typologies				
	CMSHMFS	SMCMMFS	CMMFS	SGLMFS	APPFS
	Score(rank)	Score(rank)	Score(rank)	Score(rank)	Score(rank)
Deforestation	3(3nd)	4(2nd)	4(2nd)	3(3rd)	3(3rd)
Depletion of water resources	4(2nd)	5(1st)	5(1st)	5(1st)	5(1st)
Climate/temperature change	5(1st)	5(1st)	5(1st)	5(1st)	5(1st)
Soil fertility depletion	3(3rd)	3(3rd)	3(3rd)	2(4th)	2(4th)
Soil erosion	4(2nd)	4(2th)	4(2nd)	3(3rd)	3(3rd)
Declining of grazing land	2(4th)	2(4th)	2(4th)	1(5th)	1(5th)

Source: PRA survey result, 2019

Agricultural engineering technologies use

In all study areas, improved farm implements are not used due to lack of availability of the implements by near of the farmers. Farmers limited awareness on the availability of improved implements, limited extension services on the use of improved farm implements for different operations and limited capacity of technology multiplication and distribution. For seeds and fertilizer application, farmers are commonly used traditional row planting/sowing in includes hand dropping and broad casting crops grown particularly for cereal crops.

The FGD farmers noted that planting/sowing of crops such as maize, sorghum and wheat in row is done using family labor. There is no animal drawn row planter/sow equipments available in the study area. The FGD farmers also reported that storage is a problem in the areas and the grain of sorghum, maize wheat, and haricot bean grain is affected by weevils. The mentioned that limited farmers used metal silo and sack provided by office agriculture and natural resource and NGOs for grain storage areas. There is similar situation for vegetables and fruits storage and processing technologies in all study areas. The FGD farmers reported that the major constraints to agriculture engineering technologies are lack of developing suitable to local conditions, limited promotion of improved farm tools, row planter, and fertilizer application equipment threshing machines, post harvest technologies are the major limiting factors among the others. Most of the farmers use sacks, underground storage and ground floor of their residential house as a store. There are high postharvest losses due to improper harvesting, handling, packaging and poor facilities to market.

Table 9. Matrix scores and pair wise ranking for harvest & post harvest crop related constraints

Harvest and post harvest problems	Farm typologies				
	CMSHMFS	SMCMMFS	SGLMFS	CMMMFS	APPFS
	Score(rank)	Score(rank)	Score(rank)	Score(rank)	Score(rank)
Lack harvesting technologies	1(4th)	1(4th)	3(2nd)	3(2nd)	2(3rd)
Threshing problem	3(2nd)	4(1st)	4(1st)	4(1st)	3(2nd)
Transportation	2(3rd)	2(3rd)	3(2nd)	2(3rd)	4(1st)
High storage losses	4(1st)	4(1st)	2(3rd)	0(5th)	1(4th)
Perishability crop produces	3(2nd)	3(2nd)	4(1st)	0(5th)	2(3rd)

Source: PRA survey result, 2019

Potential opportunities for improving crop production in the areas

- Availability of favorable condition for the production of best quality coffee and horticultural crops that are marketable and exported to neighboring countries Somalia and Djubuiti,
- Potential for vegetables and pulse crops production that it has become major source of income for many farmers in high land.
- Availability of multiple cropping practices like intercropping of pulses with cereals,
- Availability of favorable conditions for the production of different crops
- Proximity to domestic and export market on main highway offer another advantage for accessing agricultural inputs and for marketing agricultural products.
- Availability of perennial rivers that can services for modern irrigational purpose and ground water resource which can be used for irrigation

Conclusion and Recommendations

This study was aimed at analyzing farming systems of the East Hararghe Zone. The specific objectives of the study include characterizing and identifying farming systems, and identifying and prioritizing constraints of the identified farming systems in the study area. Multi-stage sampling techniques used to select representative districts and peasant associations (PAs). A total of 329 randomly selected farm householders for household survey and Focus group discussion (FGDs) also conducted. The collected data were analyzed using descriptive statistics and PRA tools such as pair-wise rankings. The result of PRA indicates that based on agro-ecology and major livelihood sources of farmers/agro pastoralist, five major farming typologies such as Maize/Sorghum/Chat of the highland areas of mixed farming system (CMHMFS), Sorghum/Maize perishable crops of the Midland of mixed farming system (SMCMMFS), Sorghum/Groundnut of the lowland of mixed farming system (SGLFS),Coffee/Maize mixed farming system (SGLFS) and Agro pastoral/pastoral of the lowland areas (APDLFS) were identified in the Zone. Results of PRA study revealed that the main crop production constraints were lack of improved varieties and cultivable land shortage were identified as the first limiting factor followed by insect pests, shortage of improved seeds supply, farm inputs (pesticides, fertilizers), erratic rainfall distribution/drought, soil fertility declining and extension service availability in decreasing order of priority.Similarly, livestock production in study area is constrained by ultimate animal feed shortage, drought, limited and deteriorated grazing land due to expansion of crop cultivation and limited improved forage production due to lack of adaptive and productive improved forage species that compatible to the existing farming practices has been highly affecting livestock production in farming system areas. Drought, declining of soil fertility, depletion of natural forests and deforestation were main constraints to natural resources. Hence, there is need for research, development and institutional interventions to alleviate the identified constraints to crop, and livestock production, natural resources and socioeconomic in the study area through holistic approach. Based on the findings of the study, the following recommendations are given Shortage/lack of improved varieties for maize, sorghum, wheat, barley and teff is severe in mid-highland area, introduce and promote improved varieties (high yielding, disease resistance),Improvement and introduction of improved varieties (high yielding, early maturing, tolerant to moisture stress,/drought and disease) in lowland to mid-highland areas, Sorghum and maize improvement/adaptation and introduction (high quality in nutrient, high yielding, drought and disease) in lowland to mid-highland areas, Introduce and promote efficient cropping systems for diversifying and intensifying crop production in the area. Improvement and introduction land races of sorghum varieties (early maturing and disease) in lowland to mid-highland areas,

Introduce and promote improved agronomic practices for sorghum, maize, wheat, teff, Promotion of integrated pest management for controlling of pests of cereal,increasing cropping intensity will be a key strategy, short duration pulses, oilseeds and other high value crops will find their definite niche as sequential or intercrops, rather than replacing the major cereal crops having higher yield stability, intensive diversified complementary cropping systems would enable small and marginal farmers to utilize limited land and water resources in more efficient manner.

Strengthening and capacitating farmers organizations for input and output marketing and creating linkages with value chain actors is need attention. Lack of improved varieties for pulse and oilseed crops were the major limiting factors in crop production in the study area(Lowlands, midlands and highlands),Improvement/adaptation and introduction (high yielding, drought and disease) for lowland to mid-highland areas haricot bean both food and market type, Faba bean, chickpea, groundnut Introduce and promote efficient cropping systems for pulse and oilseed crops, introduce and promote improved agronomic practices for haricot bean, promotion of integrated pest management for controlling of pests of cereal.

Improvement and introduction of improved varieties (high yielding, resistant to disease) for tomato, hot pepper, red and white onion, cabbage, carrot, potato, beetroot, w/potato, improvement and introduction improved varieties for fruit crops (Mango, Papaya, Avocado, Banana), promotion of integrated pest management for controlling disease, and improvement and introduction of improved coffee varieties (high yielding, drought, tolerant, resistant to disease, early mature).

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