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Research Article

Characterization and Analysis of Farming System in Buno Bedele and Ilu Ababor Zones of Oromia Regional State, Ethiopia

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Abstract

Farming system characterization and analysis is a roadmap for dynamic agricultural production constraints and opportunities identification and prioritization. Hence, this activity was initiated to identify and characterize the existing farming system, its constraints and opportunities in Buno Bedele and Ilu Ababor zones. A cross sectional research design with two-stage sampling was employed. Quantitative and qualitative data were collected from primary and secondary sources. A total of 386 household heads were selected for quantitative data whereas qualitative data were collected from focus group discussion and key informants via face to face interviews. Secondary data were collected from relevant published and unpublished documents. In SPSS version 20 software, simple descriptive statistics like mean, standard deviation, percentage and pair-wise ranking were used for data analysis. The result revealed that, there was a diverse crop-livestock mixed farming system where crop farming system was the dominant and characterized as rain fed and irrigation-based farming system. Cereal, horticulture, and coffee-khat-based farming systems were common in rain fed whereas few cereal and horticultural crops under irrigation farming systems were practiced in the study areas. The types of livestock reared in the areas were cattle, poultry, sheep, goats, and equines. Even though, there were numerous development supporting government and non-governmental organizations including research centers, universities, agricultural offices, climate action through landscape management (CALM) program for results project, sustainable land management (SLM) project, more young entrepreneurs in silk honey (MOYESH) project and private sectors that are contributing in crop and livestock improvement, natural resource management and job creation; high price of agricultural inputs, lack of improved seed and breeds, delay of fertilizers supply, low production and productivity, lack of capital, shortage of land, crop and livestock diseases, feed shortage, poor soil fertility, soil erosion and lack of common understanding on lime application were the major agricultural production constraints in the study areas. Therefore, all government and non-government development practitioners in the areas should consider the existing agricultural production systems, constraints and opportunities for fruitful interventions.

Keywords

Agro-ecologies, Crop, Farming System, Farming Typologies, Mixed Farming

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1. Introduction

Agriculture is backbone of Ethiopian economy where smallholder farmers are play crucial roles in economy of the country and which represents about 33.88% of its GDP [12]. It also enhances economic activities by creating job opportunities for approximately 72.7% of rural farmers and continues as a means of producing income and source of economic welfare for about 83% of the small-scale participants [6, 11]. Country's favorable diverse agro ecological zones coupled with abundant natural resources makes the agriculture sector remains a critical part of Ethiopia's economy. According to [5], the existence of diverse agro ecological conditions enables the country to grow a large crops variety and other different types of fruits and vegetables. Moreover, Ethiopia's moderate climate provides significant opportunities for dairy development, allowing the country to generate approximately 3.89 billion liters of milk annually [3].

Despite its numerous importance's, agricultural production and productivity is constrained by an interlinked factors in the country [15]. Among these constraints, depletion of natural resources, inadequate improved technology, weak institutional collaboration, pests/disease severity and price fluctuation are the main obstacles of agriculture sector development [9, 15]. For effective intervention, various agricultural production constraints and opportunities need to be extracted through analysis and characterization of farming system. As stated by [13] farming system characterization and analysis is a basic procedure to identify the point of intervention to enhance production and productivity of crop, livestock, and natural resources.

It is a roadmap for dynamic agricultural production constraints and opportunities identification and prioritization. To this end, [1] conducted farming system characterization before eight years when Buno Bedele was administrated under Ilu Ababor zone. There were numerous development supporting government and non-governmental organizations including research centers, universities, structured agricultural offices, climate action through landscape management (CALM) program for results project, sustainable land management (SLM) project, more young entrepreneurs in silk honey (MOYESH) project and a private sectors that are contributing in crop and livestock improvement, natural resource management and job creation for resource poor and youths in the study areas. Being farming system is a dynamics by its nature in one hand and scant study on analysis and characterization of farming systems in Buno Bedele zone in the other, this activity was pertinent in the study areas. Hence, this study was conducted to map farming system typologies of the zones, to identify and characterize farming system of the zones and to identify the existing farming system constraints and opportunities in the zones.

2. Research Methodology

2.1. Description of the Study Areas

The research was conducted in six districts namely Bacho, Alle and Bure from Ilu Ababor zone, and Didessa, Chora and Dega from Buno Bedele zone (Figure 1).

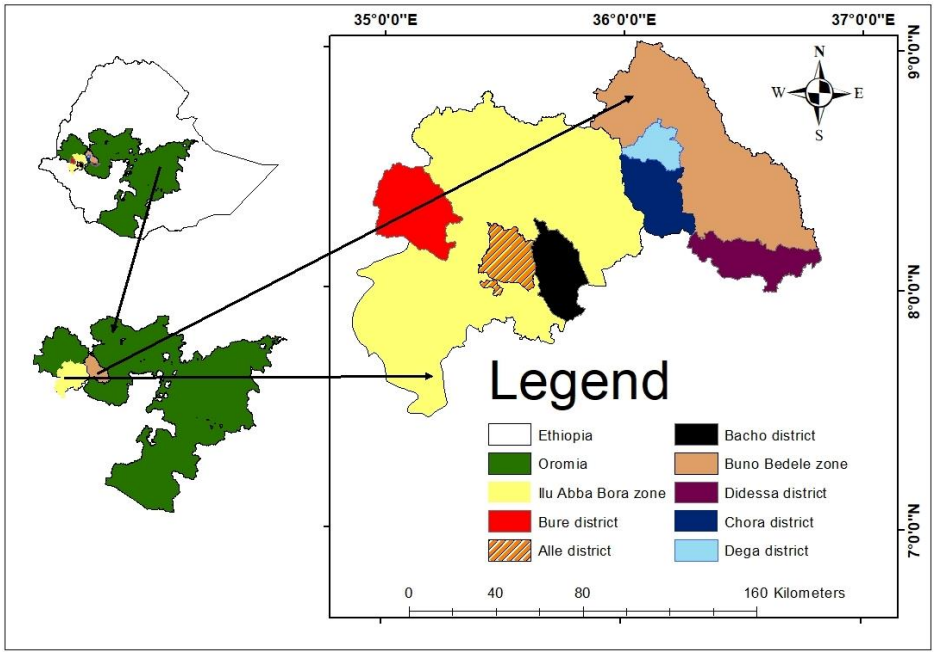

Figure 1. *Map of the study areas.*

Buno Bedele is among the zones of Oromia Regional state of Ethiopia. The zone is bordered on the east and south-east by Jimma zone, on the west by Ilu Ababor zone, on the north by East Wollega and West Wollega zones. Bedele is the administrative town of the zone. The zone is located at 8°27` - 8°45`N latitude and 36°21' - 36°35` E longitude with an elevation of 500-2575 meters above sea level. Annual precipitation of the zone ranges from 1500-2200mm with 6 to 9 months of rain fall. The zone has 9 districts and one town. Mixed crop production and livestock rearing farming system supported by off and non-farm activities are practiced as a means of income generating activities.

Ilu Ababor is among the zones of Oromia Regional state and delineated by Keffa zone on the south, by Gambela Regional State on the southwest, by Kelem Welega zone on the west, by West Wollega zone and Benishangul-Gumuz Region on the north, by East Welega zone on the northwest, and Buno Bedele zone on the east. The capital city of the zone is Mettu. It is located on 600 km distance away from Addis Ababa the capital city of Ethiopia. The zone has thirteen districts and one town. The zone is situated between longitudes of 33°47′ - 36°52′ East and latitudes 7°05′ - 8°45′ North, with the elevation ranged from 1,500–2,500 meters above sea level. Mixed farming system of crop production and livestock husbandry is the main source of income were coffee remains the leading income source.

2.2. Sampling Technique and Sample Size

Two-stage sampling method was employed to select representative districts and kebeles whereas simple random sampling was used to select representative respondents. In the first stage, all districts of Buno Bedele and Ilu Ababor zones were stratified into three agro-ecologies based on altitude, namely; highland, midland and lowland based on the traditional agro-ecological classification of respective Zonal Agricultural Offices. From each stratum, one representative district was randomly selected. Accordingly, Dega, Chora and Didessa were randomly selected from highland, midland and lowland districts of Buno Bedele zone, whereas Alle, Bacho and Bure were randomly selected from highland, midland and lowland districts of Ilu Ababor zone respectively. In the second stage, two-three kebeles were selected randomly from each stratified highland, midland and lowland districts. Consequently, eight kebeles from Dega, Chora and Didessa districts whereas nine kebeles from Alle, Bacho and Bure districts were selected. Finally, 386 households' from 17 sampled kebeles were randomly selected based on probability proportional to size (PPS) using Yemane (1967) formula at 95% confidence interval.

$$n = \frac{N}{1+N(e^2)} \quad (1)$$

Where n is the sample size, N is the population size which is 11,165 households', and e is the level of precision.

2.3. Data Type and Method of Data Collection

Both quantitative and qualitative data were collected from primary and secondary sources using semi-structured questionnaire. The questionnaires were pre-tested so as to collect relevant information that addresses the specific objectives of the study. Both qualitative and quantitative data were collected from 386 households via face to face interview, focus group discussions (FGDs) and key informant interviews. Secondary data were also collected from respective zonal, district agricultural offices and other relevant unpublished documents.

2.4. Method of Data Analysis

The descriptive statistics like mean, standard deviations, percentage and frequency were used to analyze and summarize the socio-economic, demographic, infrastructure and institutional characteristics related data of the sampled households. Participatory Rural Appraisal (PRA) tool such as pair-wise ranking was used to analyze and narrate the qualitative data.

3. Results and Discussion

3.1. Demograpic and Socio-economic Characteristics of the Households

The mean age of households was 41 years with mean family size of 6. The mean education level of the sampled households was 5 years of schooling. The mean total land holding of the respondents was 2.1 hectare where the mean land size for cultivaition was 1.1 hectare in study areas.

Table 1. *Socioeconomic characteristics of continuous variables of sample households.*

No.	Variables	N	Mean	Std. Deviation
1	Age of household heads	386	41	12.6
2	Average family size	386	6	2.5
3	Education level	386	5	3.5
4	Total land holding (ha)	386	2.1	1.8
5	Total cultivated land (ha)	386	1.1	1.0

Source: own survey result, 2023.

The result of dummy/categorical variable shown, about

97.4 percent of the sampled households were male headed with 2.6 percent were female headed. The majority of the sampled households were married (98.7%) while 0.8%, 0.3% and 0.3% were single, widows and divorced respectively. About 61.4 percent of sampled households were Islam followers which followed by Protestants (23.6%) and Orthodox (15%) in the study areas. As indicated on table 2, about 22.8 percent of the sampled households were engaged in off/non-farm activities.

Table 2. Socioeconomic characteristics of categorical variables of sample households.

No	Categorical variables	Category	Frequency	Percent
1	Sex	Male	376	97.4
		Female	10	2.6
2	Marital status	Single	3	0.8
		Married	381	98.7
		Divorced	1	0.3
		Widowed	1	0.3
4	Religion	Islam	237	61.4
		Orthodox	58	15.0
		Protestant	91	23.6
5	Participation in off/non-farm activities	Yes	88	22.8
		No	298	77.2

Source: own survey result, 2023.

3.2. Farming System Typologies of Buno Bedele and Ilu Ababor Zones

In both zones, the selected districts were characterized by mixed crop-livestock farming system scattered in three major agro-ecologies (highland, midland and low land) areas. In this study crop-livestock farming system were further classified into crop farming system which were again classified as rainfed and irrigation based farming systems (Figure 2). The rainfed farming system was subclustered into cereal, horticulture and coffee-khat-based farming systems, where cereal and horticulture-based farming systems were practiced under irrigation farming systems. Maize and tef were the dominant cereal crops whereas hotpepper and potato were the dominant horticultural crops under rainfed farming system in the study areas.

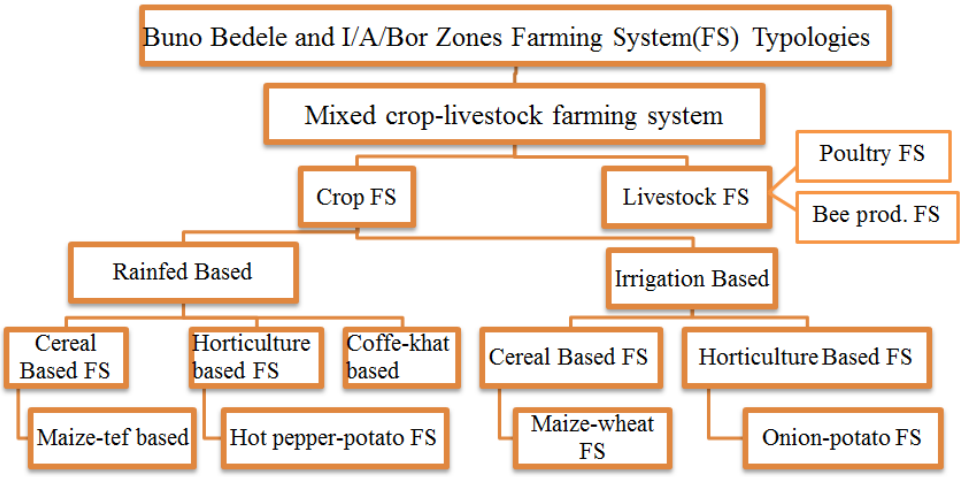

Figure 2. Hierarchal classification of farming system typologies in Buno Bedele and I/A/Bor zones.

3.2.1. Rainfed Based Crop Production System

Rainfed crop production system refers to a type of farming that relies on rainfall for crop cultivation, without the use of irrigation. Accordingly a number of cereals, horticulturals, coffee and khat were practiced under rainfed production in the study areas. The rainfed farming system also further classified into cereal, horticulture and coffe-khat based farming system.

1). Cereal Based Farming System

Maize and tef are major grown in highland, midland and lowland agroecologies while sorghum is produced in midland and lowland areas of the study areas. The survey result indicated that out of cereal crops, maize production is dominant in terms of area coverage and productivity which followed by tef production (Table 3). Out of 2.1 hectares average land holding, the mean land allocated for maize and tef in the study areas were 0.55 and 0.35 hectares which indicates about 26% and 17% of land covered by maize and tef respectively. Besides, maize and tef production; wheat is also produced by smallholder farmers. Sorghum is mostly produced in midland whereas barley produced in highland areas.

2). Horticultural Based Farming System

Hot pepper-potato based farming system

In this farming system, hot pepper is mainly produced in midland and lowland areas of Didessa and Bure districts. Survey result indicates that, hot pepper is a major horticultural crops used for both home consumption and means of income generation in Didessa and Bure districts. The highest mean cultivated land of 0.12 ha was allocated for hot pepper with the mean yield of 19.04 qt ha^{-1} in lowland agro ecologies (Table 3). Potato is also grown by smallholder farmers in highland and midland areas of Dega, Chora, Didessa, Bacho and Bure districts, while onion is produced in three major agro-ecologies of Dega, Chora and Bure districts. Tomato, sweet potato, head cabbage, beetroot, carrot and garlic are among the horticultural crops produced on small proportion of land in the study areas.

3). Coffee-khat Based Farming System

Coffee-khat based farming system is found in all selected districts of three agro-ecological zones and known as dominant cash crops where coffee is the leading cash crop in terms of area coverage, income genaration and job creation in the study areas. Survey result revealed that, the mean land allocated for coffee and khat were 0.69 ha (33% of the total land of the study areas) and 0.1 ha respectively (Table 3). Perennial fruits like avocado, banana, mango, orange, and papaya are also produced in the study areas.

Table 3. *Rain fed major crops produced per agro-ecologies.*

Farming system typology	Major Crop produced	N	Area (ha)	Agro-ecology					
				Highland (N=141)		Midland (N=160)		Lowland (N=85)	
				Area (ha)	Yield (Qt/ha)	Area (ha)	Yield (Qt/ha)	Area (ha)	Yield(Qt/ha)
Cereal based farming	Maize	386	0.55	0.53	17.1	0.56	19.1	0.54	21.87
	Tef	386	0.35	0.55	6.79	0.30	6.52	0.10	3.88
	Sorghum	386	0.03	-	-	-	-	0.10	-
Horticure based farming	Hot pepper	386	0.10	-	-	0.03	10.04	0.12	19.04
	Potato	386	0.01	0.02	18.25	0.004	8.00	-	-
Coffe-khat based farming	Coffee	386	0.69	0.5	7.23	0.80	8.79	0.94	12.20
	Khat	386	0.10	0.03	-	0.02	-	0.1	-

Source: Survey data result, 2023.

3.2.2. Irrigation Based Crop Production System

Recently Ethiopian Government has been given special attention to irrigation based crop production to ensure food security of alarmingly increasing human population in the country. Irrigation based crop production is about effective and efficient utilization of land, water and man power. Inline to this, a number of cereals and horticultural crops are produced irrigation potential areas of the study districts.

1). Maize-wheat irrigation Farming System

In all agro-ecological zones of the study areas, maize and wheat are mostly produced under irrigation farming system.

Survey results indicated that maize and wheat irrigated farming were mostly produced in highland areas of the study areas (Table 4). The FGD also confirmed that maize has a long history under irrigation system; wheat is recently introduced as irrigated wheat initiative in water sufficient areas to ensure food security and improve farmers' livelihood. However, there were limited modern schemes compared to a plentiful rivers used for irrigation and numerous irrigations interested beneficiaries in the study areas.

2). Onion-potato Irrigation Farming System

A few horticultural crops were produced under irrigation farming system for consumption and as means of income generation. Survey result indicated that, onion and potato were mostly produced specifically in lowland and midland agro-ecologies of the study areas (Table 4). In addition, beetroot, carrot, garlic and head cabbages were among horticultural crops produced in the study areas.

Table 4. Major crops produced under irrigation system.

Farming system typology	Major Crops grown	N	Area (ha)	Agro-ecology					
				Highland		Midland		Lowland	
				N	Area (ha)	N	Area (ha)	N	Area (ha)
Cereal based farming	Maize	386	0.03	141	0.05	160	0.04	85	0.001
	Wheat	386	0.02	141	0.03	160	0.02	85	0.004
Horticultural based farming	Onion	386	0.002	141	0.002	160	0.002	85	0.003
	Potato	386	0.004	141	0.01	160	0.002	85	0.001

Source: Survey data result, 2023.

3.3. Cropping System

Different cropping system with diverse management techniques were practiced where mono-cropping was the dominant followed by crop rotation and double cropping system in three major agro-ecologies of the study areas. Survey result indicated that maize based mono-cropping is the principal cropping system practiced by about 39.4% of respondents particularly in Alle, Didessa, Bacho, Chora and Bure districts of the study areas (Table 5). Crop rotation of cereal with cereal (maize-tef-sorghum), cereal with pulse (maize-haricot bean-faba bean) were also practiced within the intension to increase yield, improve soil fertility, diversify crop for home consumption and as means of income whereas double cropping was practiced by planting early maturing crop varieties like haricot bean, faba bean and barley with maize and tef in a single cropping season.

Table 5. Cropping system practiced by respondents per agro-ecology.

Types of cropping system	Total HHs	HHs (%)	Agroecology					
			Highland		Midland (N)		Lowland	
			N	%	N	%	N	%
Mono-cropping	152	39.4	50	35.5	69	43.1	33	38.8
Crop rotations	117	30.3	39	27.7	49	30.6	29	34.1
Double cropping	90	23.3	48	34.0	32	20.0	10	11.8
Inter-cropping	14	3.6	4	2.8	5	3.1	5	5.9
Coffee and Khat	13	3.4	0	0.0	1	0.6	12	14.1
Crop rotation and double cropping	48	12.4	29	20.6	16	10.0	3	3.5

Types of cropping system	Total HHs	HHs (%)	Agroecology					
			Highland		Midland (N)		Lowland	
			N	%	N	%	N	%
Crop rotation and inter-cropping	12	3.1	5	3.5	6	3.8	1	1.2
Mono-cropping and double cropping	30	7.8	14	9.9	14	8.7	2	2.4
Fallow land	53	13.7	29	20.6	14	8.8	10	11.8

Source: Survey date result, 2023.

3.4. Agronomic Management Practices

3.4.1. Land Preparation and Ploughing Frequency

In southwestern parts of the country, animal draught power is commonly used for land preparation since the landscape is not such a suitable for mechanized farming. Focus group discussion also confirmed that, smallholder farmers in the study areas are extensively depend on animal draught power for land preparation whereas, some of the farmers who have not animal draught power are prepared their small plot of land by their hand tools (hoes). Land preparation starts at the onset of the rainfall, mostly from early March based on soil and sowed/planted crop types. Focus group discussion also stated that animal draught power based plowing frequency is directly associated with crop type, rainfall distribution, weed and soil types. The survey result indicated the plowing frequency were varies due to the aforementioned features, with plowing frequency ranged from one times for field pea to five for tef in the study areas (Table 6).

3.4.2. Planting Time, Methods of Planting and Seed Rate

Time of sowing varies depending on the crop types starting from mid-April for sorghum and maize to early August for tef and bread wheat. Row planting and broadcasting methods were practiced in the study areas where broadcasting method was common particularly for sorghum, barley and field pea. Both row planting and broadcasting methods were practiced for maize, tef, wheat, faba bean, groundnut and hot pepper (Table 6). Focus group and key informants stated that, even though maize is dominantly planted through row planting method in the study areas, sole row planting method was not practiced for other crops due to its intensive labor and time requirements. Even though, using the recommended seed rate is important not only for the improvement of crop production and productivity but also for the economic profitability of the farming system as a whole. In the study areas diverse seed rate either below or above the recommended rate were practiced for different crops specifically for the major crops like maize (24.4 kg ha^{-1}), wheat (85.26 kg ha^{-1}), tef (29.39 kg ha^{-1}) and sorghum (31.75 kg ha^{-1}). Survey result indicated that, only the seed rate of maize used by the respondents was proximate to the recommended rate (Table 6).

Table 6. *Crops and their agronomic practices in the study areas.*

Crops	Sowing methods	Seed rate kg ha^{-1}	Fertilizer rate in kg ha^{-1}		Plowing frequency		Weed control methods	Weeding frequency
			NPS/B	Urea	Min.	Max.		
Maize	Row & BC	24.41	85.56	81.60	2.89	4.10	HW and CH	2.24
Tef	BC & Row	29.39	61.83	26.76	3.66	4.92	Integrated	1.80
Sorghum	BC	31.75	0	0	2.75	3.76	CH	2.20
Wheat	BC & Row	85.26	66.06	56.58	2.95	4.39	Integrated	2.07
Barley	BC	135.80	0	3.85	2.09	3.10	HW and CH	1.42

Crops	Sowing methods	Seed rate kg ha^{-1}	Fertilizer rate in kg ha^{-1}		Plowing frequency		Weed control methods	Weeding frequency
			NPS/B	Urea	Min.	Max.		
Faba bean	BC & Row	60.50	19.87	12.75	1.67	2.68	HW	1.48
Groundnut	Row & BC	65.43	0	0	2.88	3.86	HW	3.57
Field pea	BC	49.33	0	0	0.9	1.68	HW	0.35
Hot pepper	Row and BC	98.54	96.77	93.55	3.45	4.55	HW	4.48

Source: survey data result, 2023 BC= broadcasting; HW= Hand weeding; CH= Chemical.

3.4.3. Fertilizer Application Rate

In the study areas, different types of inorganic fertilizer like urea, NPS and NPSB were used with different rates across all agro-ecologies. NPSB was commonly used for major crops like hot pepper, maize, tef and wheat. However, due to its high price coupled with late delivery system numerous smallholder farmers apply fertilizers below its recommendation rate (Table 6). Unexpectedly, respondents from Guddina sor kebele in Bacho district of Ilu Ababor zone stated that, any types of inorganic fertilizers were not applied for crop production due to the remoteness of the kebeles from the district and zone. Survey result indicated that, fertilizers were not applied for sorghum, barley, faba bean, field pea and groundnut in the study areas. There is livestock tethering practice on the farm land around their home so as to improve soil fertility.

3.5. Pest Management Practices

3.5.1. Major Crop Diseases, Insects and Weeds

Southwestern part of Ethiopia specifically Buno Bedele and Ilu Ababor are known by high rainfall and relative humidity which is favorable for the development and distribution of crop diseases, insects and weeds. The aforementioned crop productivity hindering biotic factors attacks diverse crop types mainly at the very beginning of germination, vegetative, at flowering, grain filling, maturity, harvesting and even post-harvesting stages. Survey result revealed that the most common diseases recorded on maize were common smut, ear rot, gray leaf spot, turcicum leaf blight and head smut in cereal based farming system during rainfed season. The major diseases of wheat were stem rust, yellow rust and root rot during irrigation season whereas leaf rust and fusarium wilt on teff and Cercospora leaf spot, damping off, fusarium wilt, leaf blight, pod rot, root wilt, and late blight diseases were the primary causes of hot pepper damage horticultural farming system during rainfed in the study areas (Table 7).

Stem borer and fall army worm were the major insects affecting maize production. While fly shoot was also reported as a major insect on tef and wheat production. Weevil was the common maize and wheat production damaging insect at storage stage. Furthermore, termite infestation is a major problem of the study areas which was difficult to control and cause significant crop loss, from its early germination stage to the time of harvest and even to the storage.

Weeds are the primary biotic factors contributing to the loss of crop production. Various weed types that compete with the major crops for the nutrients, water and light were recorded in the study areas (Table 7). It was noted that farmers use both manual weeding and chemical applications to manage weeds. In fact the frequency of weeding varies accordance with crop, chemical and even weed types. In the study areas manual weeding was applicable predominantly for managing grassy weeds species whereas 2-4D used for broad-leaf weeds. According to FGD agro-dealers were the common herbicide suppliers with poor quality and double fold price.

Table 7. Major weeds for agro-ecology based common crops.

Crops	Major diseases	Major insects	Major weeds	Farming system	Season
Maize	Common smut, ear rot, gray leaf spot, dry root and turcicum leaf blight	Fall Army worm, weevil and stalk borer	Guzotia scabra (Vis.), Bidens pachyouma, Commelina benghalensis L., and Polygonum nepalense	Cereal based farming	Rain fed

Crops	Major diseases	Major insects	Major weeds	Farming system	Season
Tef	Leaf rust and head smudge	Shoot fly	Trifolium pratense, Eleusine indica (L.), Spergula arvensis L., Cyperus esculentus L. and Guzotia scabra (Vis.)	Cereal based farming	
Wheat	Stem rust, yellow rust and root rot	Shoot fly and weevil	Trifolium pratense, Guzotia scabra (Vis.) and Commelina benghalensis L.	Cereal based farming	Irrigation based
Hot pepper	Cercospora leaf spot, damping off, fusarium wilt, leaf blight, pod rot, root wilt and late blight	Pepper budworm, and pepper weevil	Ageratum conyzoides L. and Guizotia scarab	Horticulture based farming	Rain fed
Sorghum	Head smut, leaf blight and anthracnose	Bird attck	Bidens pachyouma, Polygonum nepalense and Guzotia scabra (Vis.)	Cereal based farming	
Potato	Late blight and bacterial wilt	Potato aphid, grean peach aphid, cutworm, red ants and leaf hopper	Eleusine indica (L.)	Horticuture based farming	Rainfed and irrigation

3.5.2. Harvesting Methods and Post-harvest Management

In all the study areas, smallholder farmers use hand tools like sickle for harvesting tef, wheat, maize, sorghum, soybean and haricot bean and threshed by animal power. However, FGD and key informant interview result indicated that a number of smallholder farmers used thresher for maize threshing. Tomato and coffee were harvested/collected using basket where tomato and onion were packed and transported to the nearest market by wooden box. Onion is harvested manually by uprooting and then separating the bulb and biomass by cutting. More number of smallholder farmers store grains in the house they live in whereas few of them were stored the grain in independent store by using silo sack (chemical diluted sack).

3.6. Major Constraints of Crop Production in the Study Areas

The result presented in table 8 revealed that there were different constraints identified across agro-ecologies. In highland areas, low productivity, shortage of fertilizer and improved seed and high price of agricultural inputs were main constraints for crop production and high price of agricultural inputs, low price of input, lack of improved seeds and fertilizers and low productivity were identified key constraints in midland areas. Shortage of fertilizer and improved seed, high improved seed and fertilizer cost, low price of output and poor soil fertility were some of the major constraints on crop production in lowland areas.

Table 8. *Major crop production constraints in the study areas.*

Crop production constraints	Agroecology								
	Highland			Midland			Lowland		
	N	%	Rank	N	%	Rank	N	%	Rank
High improved seed and fertilizer cost	131	93.0	3	157	98.1	1	80	94.1	2
Shortage of fertilizer and improved seed	134	95.1	2	146	91.2	3	82	96.5	1
Termite	39	27.7	10	30	18.7	11	17	20.0	11
Disease	43	30.5	9	69	43.2	9	42	49.4	8

Crop production constraints	Agroecology								
	Highland			Midland			Lowland		
	N	%	Rank	N	%	Rank	N	%	Rank
Insects	82	58.1	8	104	65	6	38	44.7	9
Poor soil fertility	127	90.1	4	131	81.9	5	74	87.1	4
Weed infestation	27	19.1	11	39	24.4	10	18	21.2	10
Shortage of land	104	73.8	7	99	61.9	7	53	62.3	7
Lack of capital	115	81.5	6	84	52.8	8	58	68.2	6
Low productivity	138	97.9	1	138	86.2	4	66	77.7	5
Low price of output	125	89.3	5	149	93.1	2	75	89.3	3

Source: survey data result, 2023.

3.7. Livestock Production System

Livestock production is among the existing mixed farming system in the study areas and was sources livelihood for major smallholder farmers in terms of generating income, food, draught power, transportation, manure, security against risks during crop failure. Livestock production also used as soil fertility improvement by tethering them on cultivable land which known as 'Dhayi or Mooraa Loonii in Afaan Oromoo' in the study areas.

3.7.1. Livestock Ownership

Survey result indicated that the primary livestock species reared in all agro-ecological zones of the study areas were cattle (cows, oxen, heifers, and calves), chickens, shoats (sheep and goats), and equines (donkeys and horses), listed in order of importance (Table 9). The main purposes for keeping cattle are milk production, draft power, and income generation during seasons of food scarcity. Furthermore, for smallholder farmers in the study districts, small ruminants like sheep and goats and among equine horses serve as major means of income and transportation respectively. This result is line with finding of [8] in Ethiopia where they report that, a livestock is an important source of animal protein, energy for growing crops, transportation, farming manure, buffer during crop failure, and a way to accumulate wealth.

Table 9. Types of livestock and their population in the study areas.

Livestock types	Mean livestock production		Agroecology											
			Highland				Midland				Lowland			
	M	SD	Min	Max	M	SD	Min	Max	M	SD	Min	Max	M	SD
Cow	2	2	0	15	2	2	0	30	2	3	0	7	2	2
Oxen	1	1	0	4	2	1	0	6	1	1	0	6	1	1
Heifers	1	1	0	5	1	1	0	5	1	1	0	5	1	1
Calves	1	1	0	6	1	1	0	5	1	1	0	5	1	1
Sheep	1	2	0	10	1	2	0	6	1	1	0	5	1	1
Goats	0	1	0	6	1	1	0	5	0	1	0	5	0	1
Donkey	0	0	0	2	0	0	0	2	0	0	0	4	0	1
Horse	0	1	0	3	0	1	0	3	0	1	0	2	0	0

Livestock types	Mean livestock production		Agroecology											
			Highland				Midland				Lowland			
	M	SD	Min	Max	M	SD	Min	Max	M	SD	Min	Max	M	SD
Chicken	2	3	0	10	2	2	0	14	2	3	0	10	2	3

Source: survey data result, 2023 NB: M= Mean and SD: standard deviation.

3.7.2. Livestock Production Practices

Majority of livestock species in the study areas were indigenous with small number of crossbred cattle and exotic poultry. Even though local breed cows are the major sources of milk in Ethiopia, the study result revealed that there was poor performance in terms of milk production. Most FGD and key informants explained that, feed shortage and disease over the past five years were the major causes for low milk yield in the study areas. The average milk yield gained from local dairy cow was reported to be 1 liter per cow per day while 3 L/day/cow were gained from crossbred in the study areas (Table 10). The average calving interval was about 7.83 and 5.25 months for local and crossbred cow respectively.

Table 10. *Milk production performance and lactation period of cattle in the study areas.*

Milk production performance	N	Min.	Max.	Mean	SD
Local cow average milk (L/day/cow)	321	0.00	4.00	1.18	0.61
Cross cow average milk (L/day/cow)	17	2.00	6.00	2.91	1.15
Local cow Lactation period (in month)	317	2	18	7.83	2.96
crossbred cow Lactation period (in month)	16	2	8	5.25	1.81

Source: survey data result, 2023.

3.7.3. Feed Sources and Feeding System

The agro-ecological zone, farming systems practiced and land use patterns are the main factors influencing the availability and supply of livestock feed. Survey results indicated sources of livestock feed varied depending on the land use patterns and agro-ecology where free grazing being the principal feed source in all agro-ecologies of the study areas. Similarly, the study reported by [8] demonstrated that free grazing is the most common feeding system in mixed crop-livestock farming areas. In the highland areas, a mix of tethering on private grassland and crop residues followed by free grazing and tethering on private grassland with crop residues is commonly used feed source. Meanwhile, in the midland areas, the major animal feed sources include tethering on private grassland, free grazing with private grassland and crop residues and crop residues alone. In the lowland areas, free grazing with private grassland and crop residues, as well as private grassland and crop residues were widely practiced (Table 11).

Table 11. *Major livestock feeding systems per agro-ecologies in the areas.*

Major livestock feeding systems	Proportion of livestock feeding system		Agroecology					
			Highland		Midland		Lowland	
	N	%	N	%	N	%	N	%
Free grazing /communal	175	45.3	52	36.9	84	52.5	39	45.9
Tethering on grassland	42	10.9	18	12.8	19	11.9	5	5.9
Crop residues	28	7.2	11	7.8	12	7.5	5	5.9

Major livestock feeding systems	Proportion of livestock feeding system		Agroecology					
			Highland		Midland		Lowland	
	N	%	N	%	N	%	N	%
Tethering on grassland and crop residues	45	11.7	31	22.0	9	5.6	5	5.9
Free grazing, Tethering on grassland and crop residue	49	12.7	21	14.9	15	9.4	13	15.3
Free and Tethering on grassland	6	1.6	3	2.1	2	1.2	1	1.2
Transhumances	1	0.3	1	0.7	0	0.0	0	0.0

Source: survey data result, 2023.

3.7.4. Improved Forage Utilization Status

Improved forage production and utilization were limited due to lack of awareness by several stallholder farmers' in the study areas. Survey result indicated that about 45 (11.7%) respondents practiced improved forage where elephant grass was widely practiced specifically in highland agro-ecologies compared to desho and vetiver grasses in the areas. FGD and key informants also confirmed that, next to animal feed elephant grass was used for fence whereas vetiver grass was used for soil and water conservation practice in the study areas.

Table 12. Improved forage feed utilization status of the study areas.

Parameters		Total		Agroecology					
				Highland (141)		Midland (160)		Lowland (85)	
		N	%	N	%	N	%	N	%
Improved forage technologies	Yes	45	11.7	23	16.3	15	9.4	7	8.2
	No	341	88.3	118	83.7	145	90.6	78	91.8
Which improved forage varieties/grass you used?	Elephant grass	41	10.6	24	17.0	12	7.5	5	5.9
	Desho grass	3	0.8	0	0.0	1	0.6	2	2.3
	Vetiver grass	2	0.5	0	0.0	2	1.3	0	0.0
	Not practiced	340	88.1	117	83.0	145	90.6	78	91.8

Source: survey data result, 2023.

3.7.5. Feed Shortage and Coping Mechanisms

A single natural grass of communal and private land was not sufficient for animal feed particularly during dry seasons and this inter reduces livestock production and productivities in the study areas. According to [7] low livestock production and reproduction performance, loss of body condition, slow growth rate and increased susceptibility to diseases and parasites were caused due to seasonal fluctuations in feeds supply. During animal feed shortage smallholder farmers used crop residues, transhumance to grass areas (forest land), conventional supplementary feeds (left grain mill) and palatable trees leaves.

3.7.6. Common Livestock Diseases and Parasites

A number of livestock diseases and parasites like Trypanosomiasis, Black Leg, Anthrax, Ticks, Bloat, Lamp skin, Lichen, Pastereollosis, Mastitis and Fugel were identified in

the study areas. The three most common devastating diseases in the study districts were trypanosomiasis (72.8%) and Pastereollosis (68.1%) whereas ticks (67.1%) were the serious parasite (Table 13). Agroecology is one of the primary variables determining the development of diseases. According to FGD mastitis was one of the most prevalent diseases in the highland and midland areas.

Table 13. Major livestock diseases in the study areas.

Local name	Scientific name	Respondents 'Yes' response		Agroecology					
				Highland		Midland		Lowland	
		N	%	N	%	N	%	N	%
Common livestock diseases		343	88.9	135	95.7	140	87.5	68	80.0
Gandii	Trypanosomiasis	281	72.8	108	76.6	116	72.5	57	67.1
Abbaa Gorbaa	Black Leg	97	25.1	35	24.8	43	26.9	19	22.4
Abbaa Sangaa	Anthrax	138	35.8	51	36.2	56	35.0	31	36.5
Silmii	Ticks	259	67.1	112	79.4	104	65.0	43	50.6
Bokoksaa	Bloat	232	60.1	90	63.8	98	61.2	44	51.8
Shifshaafii	Lamp skin	230	59.6	97	68.8	93	58.1	40	47.1
Dhulaandhula	Lichen	153	39.6	53	37.6	70	43.8	30	35.3
Gororsaa	Pastereollosis	263	68.1	104	73.8	108	67.5	51	60.0
Dhibee Harmaa	Mastitis	257	66.6	106	75.2	102	63.8	49	57.6
Dhibee Lukkuu	Fugel	242	62.7	98	69.5	97	60.6	47	55.3

Source: survey data result, 2023.

3.7.7. Beekeeping Practices

Beekeeping was currently encouraged by the government so as smallholder farmers and rural youths are widely practiced as the main source of income generation. As indicated in table 14, about 31.6% of the respondents practice beekeeping where traditional beehives were commonly used in highland (30.5%), in midland (20.6%) and in lowland (34.1%) agro-ecologies of the study areas. The finding is consistent with a recent study conducted by [2] in Buno Bedele and Ilu Ababor zones, which found that the majority of respondents (47.3%) used traditional beekeeping systems, with 30.1% and 22.6% using box hives and transitional beekeeping systems respectively. FGD and key informants stated that, honey production has been decreasing from time to time due to ants, birds, chemicals and pesticides, lack of bee feeds, and market fluctuations in the study areas. In a recent study conducted by [14], it was reported that honey bees are threatened by disease, pests, lack of forage, parasites, and predators.

Table 14. Beekeeping practices per agro-ecologies of the study areas.

Beekeeping		Proportion of colonies and types of beehives		Agroecology					
				Highland		Midland		Lowland	
		N	%	N	%	N	%	N	%
Honey bee colonies	Yes	122	31.6	47	33.3	43	26.9	32	37.6
	No	264	68.4	94	66.7	117	73.1	53	62.4

Beekeeping		Proportion of colonies and types of beehives		Agroecology					
				Highland		Midland		Lowland	
		N	%	N	%	N	%	N	%
Types of beehives	Traditional	105	27.1	43	30.5	33	20.6	29	34.1
	Modern	31	7.9	6	4.2	15	9.4	10	11.8
	Transitional	21	5.5	2	1.4	5	3	5	5.9

Source: survey data result, 2023.

3.7.8. Livestock Production Constraints

Table 15. Major livestock production constraints.

Livestock production constraints	Agroecology								
	Highland			Midland			Lowland		
	N	%	Rank	N	%	Rank	N	%	Rank
Disease	135	96.5	1	138	87.9	1	68	88.4	1
Shortage of animal health centers	87	62.1	7	89	56.7	5	55	71.4	3
Feed shortage	122	87.1	4	124	78.9	3	54	69.2	5
Shortage of grazing land	124	88.6	3	130	82.8	2	54	70.2	4
Lack of improved breed	129	92.2	2	123	78.3	4	63	81.8	2
Water shortage	13	9.3	8	15	9.6	8	8	10.3	8
Lack of capital	114	81.4	6	85	54.1	7	46	59.7	7
Shortage of awareness	116	82.9	5	88	56.1	6	47	61.0	6

Source: survey data result, 2023.

Livestock production is an essential component of agriculture, contributing to soil fertility improvement, food security, nutrition, poverty alleviation and economic growth. However, high livestock production and productivities are constrained by a number of factors. As showed in Table 15 diseases was a first ranked common constraint of livestock production in study areas. Lack of improved breeds, limited grazing land and feed shortages in highland as well as limited grazing land, feed shortage and lack of improved breed in midland and lack of improved breed, shortage of animal health centers and shortage of grazing land were key constraints for optimum livestock production and productivities of lowland areas in the study areas (Table 15).

3.8. Natural Resources Management

3.8.1. Land Use Land Cover

The mean land size of the selected districts is 2.08 ha, of which the cultivated and forest land are the dominant land use patterns with the mean land size of 1.08 and 0.99 ha respectively (Table 16). Being agriculture is the dominant activities in the areas, land holding size per household in each agro-ecology has been consistently declining and agricultural land has been more fragmented from time to time because of population pressure and/or land sharing among family members. Share cropping and land renting for a certain period of time were also practiced particularly by resource poor and the youngest those who have no land ownership in the farming community. In share cropping, the harvest yield was

shared equally between the land owner and the farmer who manages the land. In most cases, farmers who rent-in land also pay additional money in cash to the land owner as an incentive to sustain the contract. However, the absence of common contract and share crop land use policy and expensive agricultural inputs like improved seed, fertilizer and agro-chemicals makes the resource poor smallholder household non-profitable.

Table 16. Land use land cover per three agro-ecologies of the study districts.

Land use types	Total land use size (mean ha)		Land use land cover per three agro-ecologies					
			Highland		Midland		Lowland	
	Mean	SD.	Mean	SD.	Mean	SD.	Mean	SD.
Total land holdings (ha)	2.08	1.83	2.16	1.56	1.90	1.75	2.28	2.32
Cultivable land (ha)	1.08	1.07	1.17	0.89	0.89	0.86	1.29	1.53
Grazing land (ha)	0.29	0.53	0.34	0.47	0.31	0.60	0.18	0.46
Fallow land (ha)	0.07	0.22	0.13	0.31	0.04	0.14	0.05	0.16
Forest land (ha)	0.99	6.59	1.33	10.51	0.77	2.55	0.84	1.52
Degraded land (ha)	0.01	0.10	0.01	0.06	0.02	0.15	0.00	0.03
Rented in land (ha)	0.04	0.19	0.06	0.26	0.01	0.09	0.05	0.19
Shared in land (ha)	0.24	0.43	0.27	0.52	0.25	0.39	0.17	0.34
Shared out land (ha)	0.01	0.20	0.00	0.00	0.03	0.32	0.00	0.00
Residential land (ha)	0.16	0.09	0.18	0.13	0.15	0.07	0.15	0.05

Source: survey data result, 2023.

3.8.2. Natural and Plantation Forest

Southeastern parts of the country particularly Ilu Ababor and Buno Bedele zones are endowed by natural forest where Yayo forest is found and registered by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 2010 as a biosphere reserve for the in-situ conservation of wild Coffee Arabica. The areas are also known by plantation forests. Survey result revealed that about more than half (57.3%) of smallholder households had their own forest of which 20.5% had both natural and plantation forests followed by those had sole plantation and natural forest with the proportion of 18.9% and 18.1% respectively (Table 17). The common purpose of forest ownership in the study areas were for income generation, coffee shade/weather balance, soil erosion control, soil fertility improvement, bee keeping and for construction.

Table 17. The status of household forest ownership across three agro-ecologies.

Types of forest		Proportion of hh forest ownership		Household forest ownership per agro ecology					
				Highland		Midland		Lowland	
		N	%	N	%	N	%	N	%
Forest ownership	Yes	221	57.3	75	53.2	94	58.8	52	61.2
	No	165	42.7	66	46.8	66	41.2	33	38.8
Type of forest	Natural	70	18.1	20	14.2	28	17.5	22	25.9
	Plantation	73	18.9	28	19.9	33	20.6	12	14.1

Types of forest		Proportion of hh forest ownership		Household forest ownership per agro ecology					
				Highland		Midland		Lowland	
		N	%	N	%	N	%	N	%
Purpose of forest production	Both	79	20.5	28	19.9	33	20.6	18	21.2
	I didn't practice	164	42.5	65	46.1	66	41.2	33	38.8
	Income generation	88	22.8	28	19.9	36	22.5	24	28.2
	Soil erosion control	10	2.6	5	3.5	3	1.9	2	2.4
	Soil fertility improvement	7	1.8	3	2.1	4	2.5	0	0.0
	Coffee shade and weather balance	36	9.3	6	4.3	13	8.1	17	20.0
	For construction	4	1.0	2	1.4	2	1.2	0	0.0
	Bee keeping	7	1.8	1	0.7	5	3.1	1	1.2

Source: survey data result, 2023.

3.8.3. Agroforestry Practices

A number of agroforestry systems have been practiced by about 60.9% of smallholder farmers in the study areas. The dominant types of agroforestry were home gardens followed by coffee based agro-forestry which supports the finding of [10] conducted in Buno Bedele and Ilu Ababor zones, who found that among the identified agroforestry activities, home garden is a leading practice which followed by coffee-based agroforestry practice. FGD and key informants reported that, agro-forestry provides a number of benefits like soil-fertility improvement, food, animal feed, fuel wood, timber, medicines, for beekeeping, soil erosion control, construction/fences for livestock and human beings, shade, windbreak and recreation.

Table 18. *The status of agroforestry across three agro-ecologies.*

Types of forest		Proportion of hh forest ownership		Household's Agroforestry per Agro ecology					
				Highland		Midland		Lowland	
		N	%	N	%	N	%	N	%
Agroforestry practices	Yes	235	60.9	71	50.4	98	61.2	66	77.6
	No	151	39.1	70	49.6	62	38.8	19	22.4
Type of agroforestry	Home gardens	101	26.2	27	19.1	39	24.4	35	41.2
	Fruit based agro-forestry	9	2.3	1	0.7	6	3.8	2	2.4
	Coffee based agro-forestry	18	4.7	7	5.0	6	3.8	5	5.9
	Woodlots	14	3.6	6	4.3	8	5.0	0	0.0
	Home-gardens and windbreaks	14	3.6	6	4.3	6	3.8	2	2.4
	Home-gardens and fruit trees on cropland	8	2.1	2	1.4	4	2.5	2	2.4
	Home-gardens, woodlot and trees on rangelands	4	1.0	2	1.4	2	1.2	0	0.0
	Home-gardens, fruit trees on	8	2.1	2	1.4	5	3.1	1	1.2

Types of forest		Proportion of hh forest ownership		Household's Agroforestry per Agro ecology					
				Highland		Midland		Lowland	
		N	%	N	%	N	%	N	%
	cropland, Woodlot and wind-breaks								
	Didn't practice	151	39.1	70	49.6	62	38.8	19	22.4

Source: survey data result, 2023.

3.8.4. Soil Fertility Management

1). Soil and Water Conservation (SWC) Practices

Soil and water are among the natural resource that requires a comprehensive preservation, maintains and optimum utilization for their sustainability. Different types of soil and water conservation practices were implemented by smallholder farmers as a means of soil erosion control, soil fertility and moisture improvement. Survey result indicated majority of the respondents were practiced different soil and water conservation for different purposes of which terracing/soil bund is the dominant one in the study areas.

Table 19. The status of soil and water conservation practice across three agro-ecologies.

Types of soil and water conservation practice		Proportion of conservation practice		Agro ecologies					
				Highland		Midland		Lowland	
		N	%	N	%	N	%	N	%
conservation practice	Yes	261	67.6	91	64.5	116	72.5	54	63.5
	No	125	32.4	50	35.5	44	27.5	31	36.5
Types of soil and water conservation practice	Terraces	148	38.3	49	34.8	62	38.8	37	43.5
	Check dam	34	8.8	10	7.1	16	10.0	8	9.4
	Grasses	14	3.6	3	2.1	8	5.0	3	3.5
	Multipurpose trees	7	1.8	3	2.1	3	1.9	1	1.2
	Not practiced	119	30.8	49	34.8	39	24.4	31	36.5
	Soil bund & grasses	23	6.0	10	7.1	9	5.6	4	4.7
	Soil bund & multipurpose trees	17	4.4	10	7.1	7	4.4	0	0.0
	Soil bund, grasses & multipurpose trees	12	3.1	6	4.3	6	3.8	0	0.0
	Check dam & Grasses	3	0.8	0	0.0	2	1.2	1	1.2
Purpose of soil and water conservation practice	Reduce soil erosion	160	41.5	42	29.8	78	48.8	40	47.1
	Improve soil fertility	12	3.1	7	5.0	4	2.5	1	1.2
	Reduce soil erosion and Increase soil moisture	12	3.1	5	3.5	4	2.5	3	3.5
	Reduce soil erosion and Improve soil fertility	43	11.1	20	14.2	15	9.4	8	9.4

Types of soil and water conservation practice		Proportion of conservation practice		Agro ecologies					
				Highland		Midland		Lowland	
		N	%	N	%	N	%	N	%
	Reduce soil erosion, improve soil fertility and climate balance	14	3.6	13	9.2	1	0.6	0	0.0

Source: survey data result, 2023.

2). Soil Acidity

Respondents stressed soil acidity as the major agricultural production and productivity limiting factors in all identified farming system of the study areas. The major causes of soil acidity were mono-cropping with continuous tillage, high rain fall that causes leaching of exchangeable basic cations. To overcome soil acidity problem, a few numbers of respondents (3.2%) apply lime they got from respective district agricultural offices, research centers and universities (Table 20).

Table 20. *Households (hh) lime utilization status across three agro-ecologies.*

		Total hh lime utilization status		Lime utilization status per agro-ecology					
				Highland		Midland		Lowland	
		N	%	N	%	N	%	N	%
Lime application	Yes	12	3.1	6	4.3	3	1.9	3	3.5
	No	374	96.9	135	95.7	157	98.1	82	96.5
Methods of lime application	Based on soil test	11	2.8	6	4.3	3	1.9	2	2.4
	By estimation	1	0.3	0	0.0	0	0.0	1	1.2
	Did not applied	374	96.9	135	95.7	157	98.1	82	96.5
Source of lime	District agricultural office	7	1.8	1	0.7	3	1.9	3	3.5
	Research center	4	1.0	4	2.8	0	0.0	0	0.0
	University	1	0.3	1	0.7	0	0.0	0	0.0
	Did not get/applied	374	96.9	135	95.7	157	98.1	82	96.5

Source: survey data result, 2023.

3.8.5. Natural Resource Related Constraints

The major constraints of natural resources identified by respondents were soil fertility decline, soil erosion and lack of sustainable SWC managements in highland and midland areas. The result in table 21 shows that lack of sustainable SWC managements, soil erosion and soil fertility decline were the main top three in lowland areas of the study areas (Table 21).

Table 21. Major natural resource related constraints in the study areas.

NR related constraints	Agroecology								
	Highland			Midland			Lowland		
	N	%	Rank	N	%	Rank	N	%	Rank
Soil fertility decline	135	95.7	1	150	93.7	1	72	84.7	3
Soil erosion	127	90.1	3	139	86.8	3	75	88.3	2
Lack of sustainable SWC Managements	134	95.1	2	146	91.2	2	82	96.5	1
Lack of common understanding on SWC	109	77.5	5	104	65.0	4	58	68.1	5
Deforestation	42	29.8	6	36	22.5	7	18	21.2	7
Shortage of land for afforestation	47	33.1	7	38	23.7	6	21	24.8	6
Lack of seedling	8	6.3	8	11	6.9	8	4	4.8	8
Lack of lime accessibility	119	84.3	4	88	55.3	5	62	72.8	4

Source: survey data result, 2023.

3.9. Livelihood System of the Farming Households

3.9.1. Major Livelihood Diversification and Source of Income

Table 22. Major livelihood diversification activities in the study areas.

Major Livelihood Activities		Agroecology					
		Highland		Midland		Lowland	
		N	%	N	%	N	%
Livelihood activities	Mixed crop-livestock farming	123	87.2	133	83.1	77	90.6
	Mixed farming and off/non-farm	16	1.4	25	1.2	6	2.4
	Off/non-farm activities	2	11.3	2	15.6	2	7.1
Income sources (Birr/year)	Mixed crop-livestock productions	35,782.27		46,605.63		72,245.88	
	Farming and off/non-farm activities	19,250		27,041.67		21,150	
	Off/non-farm activities	4307.80		5193.75		7417.65	

Source: survey data result, 2023.

In the study areas, smallholder farmers diversify their livelihood into agriculture which include crop production and livestock productions, farming combined with off-farm activities and off-farm activities alone. Mixed crop-livestock farming is the leading livelihood activities and hence the source of income in all agro-ecologies of the study areas (Table 22). Survey result revealed that, more income (72,245.88 ETB per annual) was generated from crop-livestock mixed farming in low land areas compared to highland (35,782.27 ETB per annual) and midland areas (46,605.63 ETB per annual). A combination of farming and off/non-farm activities was practiced following crop-livestock mixed farming where about 27,041.67 ETB per annual was gained by smallholder farmers in midland areas. Even though all respondents participated in livelihood diversification activities in all agro-ecologies, income generated varied, which

may be due to inconsistent adoption of improved technologies, lack of awareness of improved technologies, and use of inappropriate inputs. Thus, attention is needed to improve equal dissemination and adoption of agricultural technologies across the agro-ecologies of the study areas.

3.9.2 Farming Labor Sources

In developing countries like Ethiopia, agriculture is a labor intensive activity where a number of hand tools from land preparation to threshing were used. In this case diverse farming labor sources like family labors, mutual support, and resporical, daily hired and contract labor forces are used. Table 23 shows sources of labor in crop and livestock farming and times when labor scarcity occurs frequently in agricultural production across agro-ecologies. Even though, there was a labor shortage particularly during the pick time of teaching and learning process (school open) and coffee collection, family labor was commonly used followed by a combination of family, resporical and hired labor for every activities of the farming all across agro-ecologies in the study areas (Table 23).

Table 23. *Agricultural labor sources in the study areas.*

Agricultural labor sources		Proportion of labor source		Agroecology					
				Highland		Midland		Lowland	
		N	%	N	%	N	%	N	%
Labor Source	Family labor	128	33.2	40	28.4	62	38.1	27	31.8
	Resporical/dabo	15	3.9	8	5.7	4	2.5	3	3.5
	Hired labor	9	2.3	0	0.0	3	1.9	6	7.1
	Family and hired labor	39	10.1	13	9.2	14	8.8	12	14.1
	Debo and family labors	79	20.5	34	24.1	33	20.6	12	14.1
	Family labor, Debo and Hired labor	107	27.7	44	31.2	40	25.0	23	27.1
	Dado and family labor	7	1.8	1	0.7	4	2.5	2	2.4
Labor Shortage	Yes	253	65.5	90	63.8	103	64.4	60	70.6
	No	133	34.5	51	36.2	57	35.6	25	29.4

Source: survey data result, 2023.

3.9.3. Institutional Services for Agricultural Production

This section covers institutional facilities like agricultural extension, market and credit services. Improved agricultural technologies becomes persistently used by smallholder farmers as soon as institutional services like extension and credit services as well as market accessibility are improved and used effectively. With this context, these institutional services have tremendous influences in improving technology adoption which leads to improve productivity, market-oriented production system and increase farm income in identified farming system of the study areas. FGD and key informant stated that agricultural extension services includes provision of theoretical and practical advice on crop and livestock production, natural resource management, market information and access to credit in the study areas. Different agriculture targeting government and non-government organizations like Bedele and Jimma Agricultural Research Centers, and Metu University, SLM, CALM and MOASH have a remarkable contribution in the increment of agricultural production and productivity coupled with natural resource management in the study areas. Specifically, research centers generate, promote and disseminate improved technologies and approach, SLM and CALM focused on participatory soil and water conservation practice whereas MOASH provide modern beehive for improvement of honey yield through grouping the resource poor smallholder households and youths in the study areas. The result presented in table 24 shows that 65.5% of respondents were obtained access to market information. However, the majority of respondents (73.8%) were not access to credit due to high interest rate, no interest free loan, and lack of collateral and repayment time which is not convenient for the farmers (Table 24). This study is in line with the study conducted by [4] which stated that, the majority of sample respondents had not used credit in

Dabo Hana district.

Table 24. Institutional services in the study areas.

Access to institutional services		Status HH access to services		Agroecology					
				Highland		Midland		Lowland	
		N	%	N	%	N	%	N	%
Extension Services	Yes	352	91.2	125	88.7	144	90.0	83	97.6
	No	34	8.8	16	11.3	16	10.0	2	2.4
Credit Services	Yes	101	26.2	29	20.6	48	30.0	24	28.2
	No	285	73.8	112	79.4	112	70.0	61	71.8
Access to Market Information	Yes	253	65.5	89	63.1	110	68.8	54	63.5
	No	133	34.4	52	36.9	50	31.2	31	36.5

Source: survey data result, 2023.

3.10. Agricultural Mechanization

Agricultural mechanization is a matter of labor and time saving from the early farm preparation to storage in modern farming system. It minimizes crop postharvest loses and increase land productivity as well. However in the study areas the utilization mechanized machine particularly combiner and tractor were at infant stage. This might be due to unsuitable topography, fragmented farming system, and high initial capital to buy tractor/combiner and absence of spare part.

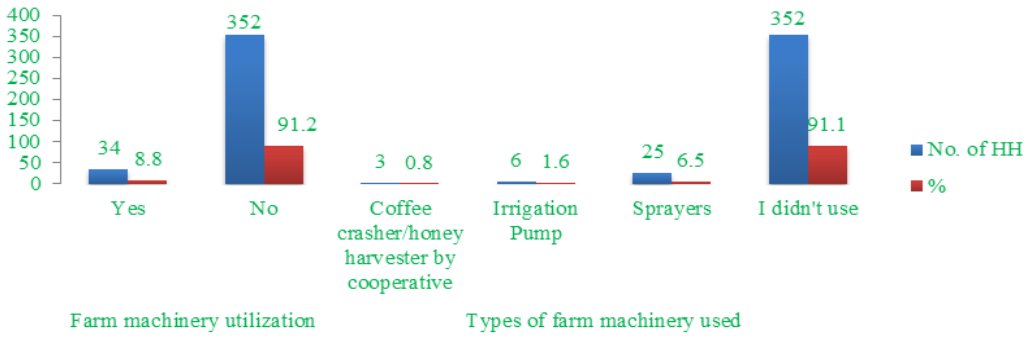

Figure 3. Farm machinery utilization statuses in the study areas.

4. Major Opportunities in the Study Areas

Even though there were different agricultural productions and productivity hindering factors, ample opportunities were available in study areas. Among the existing opportunities diverse favorable agro-ecologies for crop and livestock production, multiple agriculture supporting institutions, promising government strategies of cluster farming and farmer targeted loan provision services through Siinqee bank and the existence of perennial rivers for irrigation purpose in the areas.

5. Conclusion and Recommendations

5.1. Conclusion

Farming activity remains a central to job creation, ensure food security, economic development and agriculture based industrial expansion. However, the traditional way of agricultural activity implementations that requires intensive labor sources, animal power, time, energy and budget for every segment of activities from land preparation and planting to

threshing and storing has been practiced in the study areas. In fact a number of farming system typologies where crop-livestock mixed farming was the pillar and crop production, livestock rearing, rain-fed and irrigation based farming system, cereal, horticulture and coffee-khat-based farming systems as a branch were practiced in the study areas as means of livelihood diversification. The dominant crops were coffee, maize, tef, khat, hot pepper and sorghum whereas the livestock types reared in the areas were cattle, poultry, sheep, goats, and equines. Despite diverse farming system typologies, suitable agro-ecologies, abundant natural resources and ample agriculture supporting institutions in the study areas low productivity, shortage of fertilizer and improved seed and high price of agricultural inputs and poor soil fertility were identified as the major limiting factor across agro-ecologies. Likewise, livestock production in study area is constrained by disease, lack of improved breeds, limited grazing land, feed shortages, shortage of animal health centers and shortage of grazing land for optimum livestock production in different agro-ecologies in the study areas. Soil fertility decline, soil erosion and lack of sustainable SWC managements were main constraints to natural resources. Therefore, there is need for research, institutional involvements and development to solve the identified constraints to crop, and livestock production, natural resources and socioeconomic in the study area.

5.2. Recommendations

Based on the current findings the following recommendations have been given.

1. Crop Research

1) High yielding and disease tolerant improved crop varieties should adapt and promoted by the existing Research Centers and Universities in lowland to mid-highland areas.
2) Pure improved seed and other agricultural inputs like fertilizers and agro-chemicals should deliver with reasonable price timely for smallholder farmers in lowland to mid-highland areas.
3) Smallholder farmers should use the recommended agronomic practices through updating their indigenous knowledge rather than seeking short lifespan monetary incentive during training and experience sharing.
4) To eliminate brokers and investors' that influence agricultural input market price, government should set price for every agricultural input and follow its delivery system up to the end users.
5) Introduction and promotion of proven integrated pest management technologies in midland areas of the study areas for controlling of pests of cereal and horticulture crops based on the season of crop production.
6) Agriculture supporting finance institution should provide with appropriate repayment time, farmers owned asset based collateral credit for smallholder farmers in the study areas.

2. Livestock research and development

1) Provide sufficient drugs with reasonable price and improving the veterinary technician capacity to control animal diseases that constrained livestock production in all agro-ecologies of the study area.
2) Improve and boost community-based crossbreeding programs through AI service as shortage of crossbreeding is common to all agro-ecologies.
3) Adapt and promote improved forage suitable for the different agro-ecologies for increasing adoption in the study areas.
4) Development of veterinary service and use of proper animal farming in midland and lowland areas of the study areas.

3. Natural resources research

1) Low soil fertility is a major constraint of the study areas that is common to all agro-ecologies. So, the recommended rate of conventional and vermicompost untouched researchable agenda that may address low soil fertility in the study areas
2) Smallholder farmers should get practical training on lime use and application.
3) Create awareness on integrated soil and water conservation technologies is needed to persistent SWC management practices

4. Agricultural engineering research

Topogaraphy based agricultural machineries should introduced and promoted with necessary accessaries, spareparts, simple and on time purchasing system either for individual farmers or group of farmers in the areas.

Abbreviations

CALM	Climate Action Through Landscape Management Program for Results Project
FGD	Focus Group Discussions
CSA	Central Statistical Agency
GDP	Gross Domestic Product
MOYESH	More Young Entrepreneurs In Silk Honey
PRA	Participatory Rural Appraisal
SLM	Sustainable Land Management Project
SPSS	Statistical Packages For Social Sciences
SWC	Soil And Water Conservation
UNESCO	United Nations Educational, Scientific And Cultural Organization

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Author Contributions

Nuru Temam: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Suleiman Aman: Conceptualization, Data curation, Investigation, Methodology, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Diriba Hordofa: Conceptualization, Investigation

Conflicts of Interest

The authors declare no conflicts of interest.

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