Farming System Characterization in Selected Zones of SNNPR, Ethiopia

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Abstract:

In Ethiopia, agriculture has a significant contribution to the GDP and export items of the country. Bearing this in mind, it is important to characterize the farming system to develop climate smart and demand-driven agricultural technology for farmers. Thus, this study was conducted to explore the changes in farming systems over time and identify the factors that contributed to the change across the different agro-ecologies with cross-sectional data of 160 sample respondents. The multi-stage sampling procedure was employed to select 160 sample households. The Major means of livelihood were crop cultivation (98.44%) followed by animal rearing (93.75%) in highland and crop accounts for 94.79% and animal rearing covers 91.67% in midland areas. The major identified farming systems were enset and barley-based mixed farming system, maize-based mixed farming system, coffee-based mixed farming system, agro-pastoral farming system, and chat and enset-based mixed farming systems. The major crops in the study area were maize, common bean, finger millet, teff, potato, coffee, barley, and enset. The major livestock resources were cattle, chickens, sheep, goats, and donkeys. According to the respondents, 48(30%) had physical soil and water conservation structures on their farmland. The farming system in the study area has shown dynamism due to driving factors related to climate change and variability, land use changes, an association of farmers, and government policies. Responses of the farming systems to existing agriculture-related policy directions include the introduction of mechanization and cluster farming. The major coping mechanisms to climate change include selling livestock, buying food, eating fewer meals in a day, and storing grain for the future. Major adaptation strategies include adjusting planting dates, changing crop varieties, decreasing livestock owned, and changing crop type. In crop production among other factors, low availability of improved seed takes the upper hand with market information delivery as the prior problem. In the livestock sector, disease occurrence in production and credit unavailability for trading were top problems. In natural resource management, soil fertility among others took the upper place as a problem. Therefore, improving access to improved varieties and breeds, raising farmers' awareness of the livestock disease and improved crop management practices, working to improve market information, market infrastructure, and pricing strategies, focusing on post-harvest management practices, expanding soil and water conservation, maintaining the already constructed structure and working in improving women's access to agricultural extension services by focusing on easily participative sub-sectors are recommended.

Keywords: Crop, Characterization, Farming, Livestock

INTRODUCTION

Background and Justification

Agriculture covers 45% of the total GDP, contributes 90% of the total export, and is the main foreign currency earnings source (CSA, 2018). A 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 (Dixon et al., 2001). Pasquet (2007) also defined a farming system as "a group of intertwined activities and lines of production that a farmer and farm household conduct according to their objectives and needs, depending on changing environmental, economic, technical and cultural conditions and constraints". SNNPR is one of the largest regions in Ethiopia, accounting for more than 10 percent of the country's land area and one-fifth of the country's population. Of this amount, around 10% are estimated to live in urban areas and the rest 90% were residents in rural areas depending on crop production and livestock raising (Aynalem, 2014). The majority of farmers in the SNNPR of Ethiopia are smallholders, producing mostly for their consumption. They are estimated to generate 95% of total production for the main crops (cereals, pulses, oil seeds, vegetables, root crops, fruits, and cash crops). The average yield of the crops at all landscape positions was below optimum level due to the lack of site-specific soil fertility management, low soil fertility status, the decline in soil fertility, little fertilizer use, cultivation of steep slopes, lack of improved varieties, improper agronomic practices, lack of control of weeds, pests and diseases, rain shortage, and lack of suitable cultivars for different climatic conditions, post-harvest loss and other biological and physical factors (Alemu, et.al, 2016; Ahmed, 2017). The livestock production system is mainly extensive. Local breeds are predominant and are characterized by low milk production (Roberts and Carlo, 2014). No study was conducted to address the farming system of SNNPR in Ethiopia Therefore, to develop demand-driven agricultural technology and promote climate-smart agriculture and a market-oriented production system in the region, farming system characterization is detrimental. Moreover, this dynamism in the farming system: shifting to agroforestry system, vegetable, and root and tuber crop-based farming and change in income source, changing livelihood options, and lack of update information on farming and production system highly demands farming system characterization study. Hence, it is indispensable to undertake a farming system characterization study that is a detrimental factor for agricultural productivity maximization, adoption, and promotion of climate-smart and market-oriented production in the region.

METHODOLOGIES

Description of the Study Area

Arbegona Woreda: is one of the woredas in the Sidama Region. It is characterized by mountainous landscape having an altitude ranges from 2000 ma.s.l to 3336 m.a.s.l and 1500ma.s.l to 3700 ma.s.l respectively (Feleke et al., 2015). It exhibits a bimodal rainfall pattern. Arbegona woreda has a minor rainy season between February to April and major rainfall between July to October with annual rainfall which ranges between 1250 to1300 mm, and the temperature ranges between a minimum of 14°C and a maximum of 18°C (AWAO, 2007). The major livestock reared in the Arbegona district were cattle, sheep, goats, mules, beekeeping, donkeys, horses, and poultry (AWAO, 2007).

Halaba Zone: is found in Southern Nation Nationalities, and Peoples Region. The total area of the Woreda is 91,230 hectares of land, among that 70% flat, 27% slope and 3% mountainous. The Elevation ranges of the Woreda from 1554-2149 m.a.s.l, the mean annual Rain falls of the area ranges from 857-1085 mm, and the mean annual average temperature ranges from 17 – 20 degrees centigrade. The climatic condition of the area is 97% dry intermediate high land and 3% moist intermediate high land. The rainfall pattern is erratic and irregular in the area. Due to the severe and heavy rains, soil erosion and flooding are very common in the study area (Mesay, 2012).

Boricha Woreda: is in Sidama region. It has 588.05 sq.km² areas. Woreda is agro-ecologically categorized into two: 25% is midland (*Woynadega*) and 75% is lowland (*Kola*). *Woynadega* has medium altitude, whereas *kola* has low altitude. The altitude of woreda ranges from 1,320 to 2,080 m.a.s.l. The range of annual rainfall is between 27.82 to 128.58mm. It is bimodal with the short rainy season from March to April which is '*Belg*', and the long rainy season from June to the middle of August which is '*Kiremt*'. The range of annual temperature of the woreda is between 21.93°c to 25.56°c. The economy of the woreda is mainly based on agriculture. A mixed farming system is a dominant activity for rural households. It is confined to the production of rain-fed crops. The main crops produced in the study area are maize, haricot bean, *Enset,* coffee, potato, and sweet potato (Yoseph et al., 2012).

Dilla Zuria Woreda: Topographically, the area revealed undulated plateau at the upper limit to the valley and a plain in the lower limit. Its altitude ranges between 1750-2200 m above sea level and covers about 75,000 km². The average annual rainfall and temperature are 1300 mm and 21°C respectively. The area has two major rainy seasons (spring and summer) (Tesfahun and Temesgen, 2014).

Gedeb Woreda: Its altitude ranges from 1950 m up to 2650 m; the annual rainfall ranges from 1290 -1800 mm the temperature ranges from 16-21. The land-use system of the *wereda* is mostly a mixed farming system. Most of the land was cultivated by annual crops of 12,756 hectares, perennial crops of 16,372 hectares, and pasture land coverage of 244 hectares. The potential for cultivable land is 402 hectares; the area covered by forest and shrubs is 386 hectares, uncultivable land is 83 hectares, and 457 hectares are occupied by other uses (AGP, 2010).

Sampling Techniques

A multi-stage sampling procedure was employed to select representative sample respondents. In the first stage, Arbegona, Boricha, and Atoti Ulo *woredas* were selected purposively depending on their representativeness in the existing socio-economic, socio-cultural, and agro-ecological diversities of the targeted population of the zone. In the second stage, the kebeles were stratified based on farmers' farming system clusters to capture the existing socio-economic, socio-cultural, and agro-ecological diversities of the targeted population. In the third stage, nine *kebeles* (four from highland and five from midland) were selected purposively from the farming system cluster with the consultation of experts from each district based on the existing socio-economic, socio-cultural, and agro-ecological diversities of the targeted population of each *woreda*. Finally, 160 sample respondents were selected randomly from strata based on proportional probability size.

Method of Data Analysis

Qualitative data collected during focused group discussion and key informants' interviews were presented in narration. Quantitative data were analyzed using STATA software and the results are presented in descriptive statistics such as minimum, maximum, mean, standard deviation, frequency, and percentage based on the type of data.

RESULTS AND DISCUSSION

Demographic and Socio-Economic Characteristics of Respondents

As presented in Table 1, the average age (t=-2.58) and education levels (t=2.85) of the sampled households in terms of comparison between highland and midland showed a statistically significant mean difference. Midland farmers are more aged than that of highland areas which might increase experience in years of engagement in farming activities. Among the total sample

respondents, about 93.12% were males and 6.88% were female household heads. Concerning marital status, 88.74% were married, 8.13% were single and 3.13% were widowed. Crops cultivation remains to be a dominant economic activity and source of livelihood in the two agro-ecologies with 98.44% and 94.79% of respondents have participated in highland and midland agro-ecologies respectively. Animal rearing, beekeeping, nonfarm and off-farm activities take the next consecutive shares (in the case of highland agroecology 93.75%, 15.63%, 14.06%, and 7.81%, and midland they account for 94.79%, 91.67%, 28.13%, 9.38%, and 7.29% respectively). There is a statistically significant difference between highland and midland in terms of the percentage contribution of animal rearing and beekeeping as a means of livelihood earning activities.

Table 1: Summary of demographic and socio – economic characteristics of respondents

Variables		Midland n = 96	Highland n = 64	Overall n = 160	χ^2/t- test
Age (years)		41.95	37.17	40.04	2.58**
Education status		4.66	6.45	5.375	-2.85**
Family size		7.55	7.9	7.69	-0.52
Sex (male)		86 (89.58)	63 (98.44)	149 (93.12)	4.70**
Marital status	Married	81 (84.34)	61 (95.31)	142 (88.74)	5.40*
	Single	10 (10.42)	3 (4.69)	13 (8.13)	
	Widowed	5 (3.13)		5 (3.13)	
Crop cultivation HHs (yes)		94.79%	98.44%		1.40
Animal rearing HHs (yes)		91.67%	93.75%		3.32*
Off – farm activity HHs (yes)		7.29%	7.81%		0.01
Non – farm activity HHs (yes)		9.38%	14.06%		0.85
Beekeeping activities (yes)		28.13%	15.63%		3.28*

Source: Survey result, 2021

Land Ownership

Land tenure and how the land under the farmers' control was utilized were observed in the study. The result in Table 2 shows that there is a statistically significant mean difference between highland and midland agro-ecologies in terms of average lands allotted to grazing (t=2.32) and multipurpose tree plantation purposes (t=4.54). This implies on average higher hectares of land allotted to grazing and multipurpose trees in highland areas.

Table 2: Summary of land tenure

Variables	Highland n = 64				Midland n = 96				t – test
	Mean	Min	Max	S. D	Mean	Min	Max	S. D	
Total Land	1.41	0.27	3.59	0.81	1.52	0.27	3.47	0.83	-0.82
Annual crop land	0.69	0.02	2.5	0.50	0.98	0.02	2.5	0.84	-1.38
Perennial crop land	0.35	0.03	0.75	0.20	0.25	0.03	0.75	0.24	1.49
Grazing land	0.15	0.11	0.23	0.06	0.13	0.11	0.23	0.04	2.32**
Multipurpose trees	0.11	0.01	0.25	0.10	0.05	0.01	0.25	0.02	4.54***

Source: Survey result, 2021

Types of Farming Systems in the Study Areas

As per the survey results and using (USAID, 2005), the following five types of farming systems were identified in the study area to help development practitioners get acquainted with the potential areas of agricultural production system:

Enset and Barley-Based Mixed Farming System:

Sidama-Gedeo highland enset and barley potential growing areas are included in this type of farming system. This group includes the Arbegona, Hulla, Bensa, Aroresa, frm Sidama, and Bule, and Kochere from Gedeo. With slope percentages ranging from 5 to 20 percent, the topography is hilly. The year-round low temperatures are a result of the area's altitude, which ranges from 2100 to 3200 meters above sea level. Very little vegetation is present, and the predominant soil type is a brown clay loam. With about 350 persons per square kilometer, the population density is average when compared to the nearby midland coffee-producing areas. Mixed farming is common. The primary food crops are enset, barley, wheat, horse beans, peas, and maize, in decreasing order of importance. The three main income crops in this classification are garlic, cabbage, and shallots (known locally as kitel *shinkurt*). Although some farmers use animal traction, the majority cultivate by hand. Cattle, sheep, and horses are the three principal categories of livestock raised. The majority of farmers have their own grazing land and typically raise more animals than other farming systems. This is due in part to larger land holdings, places that can only be used for grazing due to flooding, and relatively abundant pasture throughout most of the year due to rainfall. There is a seasonal movement of livestock to the valleys surrounding the Arsi and Bale administrative zones of the Oromiya Region during May and June, the two months when grass and crop residues are less readily available locally. Due to the lack of all-weather roads, this farming system areas have low market accessibility from the highland region of Arbegona woreda. In this area, doing local casual employment is viewed as shameful. Poor households avoid working locally as a result, moving elsewhere during harvest to adjacent coffee-growing regions. During times of peak production, better-off households engage communal labor to cultivate their fields while feeding and giving drinks to the workers.

Maize-Based Farming System:

It covers the lowest areas of the Sidama region like portions of Hawassa, Dale, Aleto Wondo, Dara, Bensa, and Aroresa woredas, Boricha woreda, parts of Gedeo zone, such as Dillazuria woreda, and the majority of Halaba zone. Although many officials refer to it as lowland or kolla, it actually lies on the border of the kola and woinadega agro-ecological zones, with elevations between 1400 and 1700 meters above sea level. The belg and kremt rains, which occur twice a year, bring about an average rainfall of 700 to 1200 millimeters. Plains and undulating hills make up the landscape. The population heavily relies on artificial ponds and shallow wells for water for both people and cattle because there aren't many rivers that traverse this farming system.

These have a tendency to dry out between December and February, which poses a serious issue for the availability of water. The major crop, maize, is only planted once a year, therefore farmers identify themselves as being belg-dependent due to the importance of the belg rains in March and April for crop production. Irish potatoes, sweet potatoes, and other food crops like haricot beans can be planted twice a year, during each rainy season. Farmers intensify the area planted with these quickly growing crops during the ensuing meher season to make up for the lost corn when the belg rains are insufficient and maize production fails. In the majority of this Sidama agricultural system area, enset is planted as a perennial food crop. But compared to the close-by midland and highland parts of Sidama, it is less significant here. This farming system consists of coffee, chat, and hot peppers. Both hand cultivation and, for some wealthier households, oxen-pulled plows are methods of land preparation. The principal animals raised in the Sidama Maize Belt are cattle, goats, and donkeys. Since pasture and browse are easier to acquire by in the lower, more remote places, it is common to keep cattle and goats there. Donkeys are necessary for the transportation of firewood, water, and goods for trade.

Coffee Based Farming System:

It covers the midland (*woinadega*) areas of the Sidama region parts of Dara, AletoWondo, Dale, Shebedino, Awassa, Hulla, Bensa, and Aroresa woredas. In addition, it includes Yirgachefe areas of the Gedeo zone. Altitudes range from 1700–2300 meters above sea level. The landscape is characterized by undulating hills and, due to the high population density, most of the land is cultivated. This is a visibly green part of with, with eucalyptus, fruit, and coffee trees prominent and enset stems growing around every house. However, there is no natural forest and very limited communal grazing land. Rainfall in this farming system is more reliable than in the neighboring maize belt and falls during two rainy seasons, the *belg* and *kremt* rains.

Coffee is the main cash crop and enset is the main food crop, and these are supplemented by small quantities of other rainfed food crops (including maize, haricot beans, and sweet potatoes) and fruits (including avocado and pineapple). Annual food crops are generally intercropped amongst the coffee and enset plants. As a result, plow oxen are rarely used for cultivation in this farming zone; most cultivation is done by hand. Due to small landholding sizes and the large proportion of land that is dedicated to coffee production, most households do not produce enough food crops to last throughout the year, even in a year of good crop production. Market reliance is therefore quite high in this farming system, suggesting that both cash crop and staple food prices should be closely monitored.

Agro-Pastoral Farming System:

It covers the western lowlands of Boricha and Dale woredas in the Sidama region. The southern part of this farming system area borders the Oromia region. The topography of the zone is mainly flat, with a gentle decline from east to west, where the large perennial Bilate River provides a boundary. The altitude range is from 560-1700 meters above sea level. Lower areas of the livelihood zone are covered with relatively dense bush, while higher altitude areas have less vegetation cover. Farmers plant along the river and use the area between high cliffs to the east and the river to the west for grazing in a communal grazing area with lots of bush and grass. The soil type is mainly sandy loam of grey color and, because it is susceptible to erosion, gullies and gorges cross the zone. The zone is full of termite hills, which affects the availability of cultivable and grazing land. This is a low rainfall area with a sporadic rainfall pattern during the two rainy seasons. The *belg* rains fall from February to April and the *kremt* rains from July to early October. Temperatures are relatively hot, ranging from 26oc -33oc. Households live together and share resources in common. They have significant livestock numbers per household, and livestock and livestock product sales are the main cash income sources. The types of livestock reared in the zone are cattle, goats, sheep, and donkeys (in descending order of importance). There is a large amount of communal grazing land in the Bilate Valley, which attracts additional livestock from the neighboring Sidama Maize Belt. There is no outmigration of livestock. The main staple food crops in the zone are maize, haricot beans, *enset*, and sweet potato, all produced in relatively small amounts. Chat is an income-generating crop in the higher-altitude areas of this farming system, but it is not typical as a whole. Farmers use animal traction to plow their land and they have both rainfed and irrigated land. Excessive rains are beneficial in one sense, allowing pasture to flourish, and detrimental in another sense, flooding irrigated crops. The opposite is true in drought years: livestock, pasture, and rainfed crops suffer, while irrigated crops thrive. On balance, agro-pastoralists in this livelihood zone prefer to have heavy rains, reflecting the importance of livestock over crops.

Chat and Enset-Based Farming System:
This system of farming includes Wondogenet woreda of the Sidama region. It has a bimodal rainfall pattern, with the *belg* rains falling from February – April and the *kremt* rains falling from June – October. Temperatures range from 16°c – 28°c. Mixed farming is the main agricultural system in this farming system. Chat, sugarcane, avocado, mango, and vegetables like head cabbage are the main cash crops. Enset, maize, haricot beans, and Irish potatoes are the main food crops.

Crop Production in the Farming System:
Major Crops and Productivity:
In both highland and midland areas, the farmers are practicing mixed farming at the subsistence level. Crop cultivation in the study areas mainly depends on the rain-fed system. Major crops grown by farmers in the study areas were summarized in Table 3. Maize, common bean, finger millet, potato, coffee, barley, and enset were the most important crops in the highland and midland agro-ecologies while barley was grown only in highland agroecology. Finger millet and teff were confined to midland areas in production. In addition to these major crops on the side of midland crop items, the Arbegona district of the Sidama region and Gedeb district from the Gedeo Zone are well known for growing vegetables (head cabbage primarily) which are worth attention. From a highland agro-ecological setting, the Dilla Zuria district is endowed with the potential to grow fruits like avocado, mango, and banana in addition to those as crops of midland areas. Boricha district of Sidama region requires the focus of intervention in research and development of vegetable production like head cabbage and sugarcane. There is a statistically significant mean difference in yield per hectare of maize, common bean, and potato crops between the two agro-ecological settings.

Table 3: Summary of major crops and their productivity

Major crops	Highland (n =64)				Midland (n =96)				Yield/ha t - test
	%HHs grown	Area (Ha)	Total prdn	Yield (Qt/ha)	%HHs grown	Area (Ha)	Total prodn	Yield (Qt/ha)	
Maize	21.88	0.37	148	37.35	70.83	0.67	1052	30.74	1.99*
Common bean	4.69	0.55	21	12.5	38.54	0.34	171	13.5	-8.38***
Finger millet	-	-	-	-	37.5	0.47	198	11.8	-
Teff	-	-	-	-	16.67	0.21	45	13.4	-
Potato	7.81	0.27	22	20.11	28.13	0.58	896	61.85	-2.33**
Coffee	10.94	0.10	9.07	13.79	28.13	0.15	44.85	11.53	1.16
Barley	62.5	0.85	602	17.8	-	-	-	-	
Enset	70.31	0.39	-	-	23.96	0.35	-	-	

Source: Survey result, 2021

Improved Variety and Agronomy Use Practices:
As shown in Table 4 below, the use of improved variety and row planting practices are shown as the percentage of total producers of each major crop. In highland areas, the use of improved varieties for maize, common bean, potato, coffee, and barley accounts for 85.71%, 66.67%,60.00 %, 28.57%, and 72.50% respectively. Row planting agronomic practices in highland for maize, common bean, potato, coffee, barley and enset accounts for 78.57%, 33.33%, 80.00%, 42.86%,85% and 20.00% respectively. Varieties being used for maize in highland areas include

BH-661. The dominant variety of barley is Eboni. The common bean variety includes Hawassa Dume. In midland areas, the use of improved varieties for maize, common bean, finger millet, teff, potato, coffee, and barley accounts for 88.24%, 81.08%,19.44%, 43.75%, 81.48%, and 22.22% respectively. Row planting agronomic practices in midland for maize, common bean, finger millet, teff, potato, coffee, and enset accounts for 76.47%,72.97 %,25.00%, 37.50%, 74.07%,29.63%, and 21.74% respectively. In the case of midland agroecology, maize varieties include Limu, Shone, and Damot. The potato varieties are Tadesse and NechAbeba. The dominant common bean varieties are HawassaDume and to some extent Nasir. The improved variety of Teff typical to the study area is Cross-37.

Table 4: The use of improved varieties and row planting

Crop	Highland (n =64)	Midland (n =96)	χ^2/t- test
Maize improved varieties users	85.71	88.24	0.08
Maize row planting	78.57	76.47	0.09
Common bean improved varieties users	66.67	81.08	4.12**
Common bean row planting	33.33	72.97	22.02***
Finger millet improved varieties	-	19.44	
Finger millet row planting		25	
Teff improved variety users	-	43.75	
Teff row planting		37.5	
Potato improved variety users	60.00	81.48	9.22***
Potato row planting	80	74.07	0.006
Coffee improved variety users	28.57	22.22	0.81
Coffee row planting	42.86	29.63	2.89*
Barley improved variety users	72.50	-	
Barley row planting	85		
Enset improved varieties	-	-	
Enset row planting	20	21.74	0.02

Source: Survey result, 2021

Grain Storage Practices in the Study Areas:
Grains are stored in locally made structures using woods and byproducts of crops like maize. These structures make the stored crops vulnerable to attacks by weevils, rodents, and fungal attacks because the nature of the surface area of locally made structures is not safe enough to prevent rodents, and no remedies to contain the effect of excessive heat. Farmers try to control storage-related problems by using a combination of techniques like applying ashes, Smoking, and spraying chemicals.

Agricultural Mechanization in the Study Areas:
The use of mechanization is confined to areas of agricultural commercialization clusters that have been established in collaboration with the Agricultural Transformation Agency (ATA) in areas like the Halaba zone.

According to the survey result, the use of animal draft power is 36.25%. The percent of mechanization in terms of the use of a tractor is 8.13%. These respondents were from Atoti Ulo woreda, Halaba zone. There were no respondents who reported having used combiners for harvesting crops.

Major Constraints in Crop Production:

According to the response of farmers and experts, low availability of improved seeds, the high price of agricultural inputs, delay of inputs, variability of crop varieties coming into the hands of farmers, erratic nature of rainfall, inadequate market infrastructure, lack of market information, lack of processing units, lack of modern storage facilities and price fluctuation were major constraints in production and marketing aspects of crops (Table 5).

Table 5: Crop production and marketing constraints

Production constraint	Rank	Marketing constraint	Rank
Low availability of improved/hybrid seed	1	Inadequate market infrastructure	1
The high price of agricultural inputs	2	Lack of market information system	2
Delay of the inputs at the required time	3	Lack of processing units	3
Variability in the type of crop varieties coming into the hands of farmers	4	Lack of modern storage facility	4
Erratic nature of rainfall	5	Price fluctuation	5
Shortage of farm implements and labor	6		

Source: Survey result, 2021

Livestock Production in the Farming System:

Livestock Ownership:

Livestock ownership statistics of sampled households are summarized in Table 6, with the percent of respondents owning the livestock types and average TLU. About 10.94% had oxen herd size of 1.83 TLU in highland and 39.58% with 2.00 TLU herd sizes oxen in midland. Of total respondents, 50.00% were with 3.48 TLU cow herd size and 41.67% with 2.05 TLU cow herd size in highland and midland respectively.10.94% of respondents were with 2.00 TLU bull herd size and 11.46% were with 1.18 TLU herd sizes of a bull in highland and midland respectively. In terms of a heifer, 28.13% with 1.76 TLU and 4.17% with 1.31 TLU heard the size of heifers is owned highland and midland respectively. The population of calves was 26.44% with 0.48 TLU and 12.50% with 0.43 TLU in highland and midland agro-ecologies respectively. Chicken population ownership is 26.69% with 0.03 TLU and 42.71% with 0.07 TLU in highland and midland respectively. Sheep ownership is 25.00% with 0.54 TLU and 20.83% with 0.49 TLU in highland and midland respectively. Goats are exclusive to midland agroecology with 26.04% and 0.41 TLU. Donkeys account for 14.58% with 1.00 TLU. There is a statistically significant mean difference between highland and midland in terms of Cow, bull, and chicken TLU.

Table 6: Household livestock ownership, the proportion of owners, and herd sizes (TLU)

Types of livestock	Highland(n=64)		Midland(n=96)		t- test
	%HHs	Mean TLU (std)	%HHs	Mean TLU (std)	
Oxen	10.94	1.83(1.33)	39.58	2.00(0.81)	-0.4291
Cow	50.00	3.48(2.12)	41.67	2.05(1.06)	3.65***
Bull	10.94	2.00(1.00)	11.46	1.18(0.40)	2.45**
Heifer	28.13	1.76(1.12)	4.17	1.31(1.13)	0.72
Calves	26.44	0.48(0.17)	12.50	0.43(0.21)	0.69
Chicken	29.69	0.03(0.01)	42.71	0.07(0.04)	-4.31***
Sheep	25.00	0.54(0.38)	20.83	0.49(0.36)	0.46
Goat	-	-	26.04	0.41(0.28)	-
Donkey	-	-	14.58	1.00(0.45)	-

Source: Survey result, 2021

Animal Feed Technologies:

As indicated in Table 7, the major sources of feeds for livestock in the study area were cut and carry system (55%), use of improved forage (48.75%), crop residues (46.25%), and concentrates of different feed types (21.87%) in their order of importance. The major types of available improved forages in the study area were desho grass (31.25%) and elephant grass (16.25%) as significant contributors to the livestock feeding for farmers.

Table 7: Sources and types of livestock feeds

Sources of feed	n = 160	%HH	Types of improved feed	n = 78	%HH
Cut & carry system	88	55.00	Urea treated straw	-	-
Hay making	27	16.88	Desho grass	50	64.11
Crop residues	74	46.25	Elephant grass	26	33.33
Concentrates of different types	35	21.87	Tree Lucerne	-	-
Improved forages	78	48.75	Susbania	-	-
Local beverage products	7	4.38	Oat-vetch	-	-
			Multi-nutrient block	2	2.56

Source: Survey result, 2021

Practices of Breeding Cows:

Different breeding practices used by the respondent for cows are shown below in Table 8. The major ones were uncontrolled bull service, AI/natural heating, controlled improved bull service, AI/ synchronization, and Improved bull service/uncontrolled in their order of importance with 75%, 8.13%, 6.88%, and 5% (both AI/synchronization and Improved bull service/uncontrolled) respectively.

Table 8: Summary of cow breeding practices

Types of breeding practices (N=160)	N	%HHs
AI /natural heating	13	8.13
AI/synchronization	8	5.00
Improved bull service/controlled	11	6.88
Improved bull service/uncontrolled	8	5.00
Local bull service/uncontrolled	120	75.00

Source: Survey result, 2021

Beekeeping Practice:

Beekeeping is a common practice in rural livelihoods as an income generation source and home consumption. As presented in Table 9, beekeeping practices and production of honey. The result shows that a few percent of the respondents in the survey areas own beehives in general (23.75%). Traditional, transitional and modern beehives were owned by 16.25%, 6.25%, and 7.5% of the respondents respectively.

Table 9: Summary of beekeeping practice

Beehives	n = 86	%HHs	Honey harvest Mean (SD)
Own beehives	38	23.75	-
Traditional beehives	26	16.25	23.04(17.61)
Transitional bee hives	10	6.25	13.25(10.00)
Modern bee hives	12	7.5	55.00 (28.87)

Source: Survey result, 2021

Livestock Production and Marketing Constraints:

Table 10 below indicated that disease, lack of improved breeds, inadequate accessibility of veterinary service, lack of credit, no nearby market, and absence of market information were major production and marketing constraints that impair the performance of the livestock sub-sector.

Table 10: Summary of livestock production and marketing constraints

Production constraint	Rank	Marketing constraint	Rank
Prevalence of livestock diseases	1	Inadequate availability of credit	1
Biological limitation of indigenous breeds	2	Poor access to organized markets	2
Shortage of feed	3	Absence of market information	3
Inadequate accessibility of veterinary service	4	Unregulated trading	4
Deficiency of vaccine and vaccine set-up	5		
Limited availability of quality breeding purpose bulls.	6		

Source: Survey result, 2021

Crop and Livestock Diseases in the Study Areas:

Milly bugs, rodents, aphids, white scale, and rust were major crop diseases and pests reported by the sampled respondents in the study area. Trypanosomiasis, blackleg, liver disease, anthrax, gororsa, CBPP, trypanosomiasis, pasteurellosis, coughing, and mastitis were the main livestock diseases, pests, and parasites are indicated in the table below Table 11.

Table 11: Summary of crop and livestock diseases in the study area

Crop disease/pests	Crop type affected	Prevalence area
Milly bug, rodents	Enset	Gedeb
Aphid	Head cabbage	Gedeb
White scale	Mango	Dillazuria
Rust	Wheat	Gedeb
Livestock disease/parasites	**Livestock type affected**	**Prevalence area**
Gendi(triphanosomiasis), Aba gorba (blackleg), Liver disease (Yegubetbeshita)	Cattle	Gedeb
Aba senga(antrax)	Cattle, sheep and equines	Gedeb, AtotiUlo
Ovinepastoralisis (Gororsa)	Cattle and sheep	Gedeb
Contagiousbovinepleuropneumonia (CBPP)	Cattle, goat, sheep	Dillazuria
Trypanosomiasis	Cattle	Dillazuria, Atoti
Pasteuorolosis	Goat and sheep	AtotiUlo
Blackleg	Cattle, goat, sheep	Dillazuria
Coughing	Sheep, poultry, and equines	Gedeb
Mastitis	Cattle	Arbegona

Source: Survey result, 2021

Natural Resource Management Practices in the Farming System:

Physical Soil and Water Conservation Structures:

According to the respondents, 48(30%) had physical soil and water conservation structures on their farmland while the issue of repairing the already constructed structures was given little attention at a time of mobilizing farmers for mass physical and biological soil and water conservation activities movement at a local level.

Types of Physical Soil and Water Conservation Structures:
Major types of physical soil and water conservation structures available in the study area were soil bund, terracing, fanyajuu, and gully stabilizer with 39.58%,37.50%,20.83%, and 2.08% proportion of households having them on farmland respectively (Table 12).

The results imply that due to variation in slopes, in highland areas terraces and soil bunds are dominant, whereas in midland areas soil bund takes the upper hand.

Table 12: Types of physical SWC structures

Types of SWC structures (N=48)	Highland		Midland		Total		χ²
	N	%HHs	N	%HHs	N	%HHs	20.45***
Terracing	13	76.47	5	16.13	18	37.50	
Soil bund	2	11.76	17	54.84	19	39.58	
Fanyaju	1	5.88	9	29.03	10	20.84	
Stone bund	-	-	-	-	-	-	
Gully stabilizer	1	5.88	-	-	1	2.08	

Source: Survey result, 2021

Forestry and Agroforestry:
Gedeo zone is widely renowned for its agroforestry in comparison to other research areas. The area's upper story is primarily made up of native tree species such as Ficus spp., Cordia africana, Croton macrostachyus, and Millettia ferruginea, as well as fruit trees like mango (*Mangifera indica*) and avocado (*Persea americana*). The middle story is made up of dominant species like enset (Ensete ventricosum), a huge non-woody evergreen perennial herb, and coffee (*Coffea arabica L.),* an evergreen shrub. Vegetables, spices, and herbs frequently occupy the lower story. While enset is present at all elevations, the coffee component declines with elevation.

The Arbegona Garemba forest woodland in the Sidama region is renowned for its abundant flora. The vegetation of Arbegona Garemba woodland is comprised of alpine bamboo and damp evergreen Afromontane Forest. There are scattered ruminant trees in the area, including *Hagenia abyssinica, Juniperus procera, Olea Africana, Hypericum revoltum, and Erica arborea*, indicating that these species once dominated the middle and lower portions of the area's vegetative cover.

Among the faunal species are the Fan-tailed raven (*Streptopelia lugens*), Thick-billed raven (*Galerida theklae*), Alpine chat (*Cercomela sordida*), Mountain thrush (*Turdusoli vaceus*), Rupels robin chat (*Cossyphase mirufa*), Wattled ibis (*Cinnyris venustus*), Alpine swift (*Tachymarptis melba*), Dusky turtle dove (*Tockusalboter minatus*) and Red-winged starling (*Buphagusery throrhyncus*) are some of the avifauna species found in Arbegona Garemba forest. In Halaba dominant species include *Acacia albida, Sesbania,* and *Leucaena* which are found sparsely.

Major Constraints of Natural Resource Management:
Natural resource management practices are being undertaken in the study areas largely by community-based mobilization and to some extent the help of non-governmental agencies. However, the efforts are constrained by the challenges indicated below in Table 13. The use of inorganic fertilizers is not sufficient unless technologies like vermincompost are introduced to farmers.

Table 13: NRM production and marketing constraints.

Constraints	Rank
Declining soil fertility	1
Soil erosion and loss of topsoil, drought,	2
Land shortage	3
deforestation	4
soil acidity	5
lack of adequate knowledge of NRM management practices	6

Source: Survey result, 2021

Institutional Setting in the Study Areas:

Access to Credit for Agricultural Activities:

It is a fact that credit is the most important in technology adoption in terms of input purchase. Those who had access to credit/utilized credit services were 47(29.38%) of the total respondents. As indicated in Table 14, the purpose of taking credit was livestock production, crop production, trade, social issues, and purchase of food with 44.68%, 31.91%,8.51%,8.51%, and 6.38% respectively. The overall result indicates that much of the need inclines for purchase of livestock assets and crop production.

Table 14: Purposes of utilizing credit services

Purposes (N=47)	Highland		Midland		Total		χ²
	N	%HHs	N	%HHs	N	%HHs	16.92***
Livestock production	6	23.08	15	71.43	21	44.69	
Crop production	12	46.15	3	14.29	15	31.91	
Trade	4	15.38	-	-	4	8.51	
Social issues/health, wedding	1	3.85	3	14.29	4	8.51	
Purchase of food	3	11.54	-	-	3	6.38	

Source: Survey result, 2021

Sources of Credit for Agricultural Activity:

The major sources of credit for agricultural activities are the respondents were microfinance institutions, friends/relatives/neighbors, and informal saving and credit institutions like "ikub" with 51.06%, 42.55%, and 6.39% respectively (Table 15). This implies that farmers are mostly reliant on friends' relatives and neighbors for loan in case microfinance services are not available.

Table 15: Summary of sources of credit for agricultural activities

Responses (N=47)	N	%HHs
Microfinance	24	51.06
Informal saving and credit institutions	3	6.39
Friends, relatives, neighbors	20	42.55
Banks	-	-
From coops/unions	-	-

Source: Survey result, 2021

Access to Extension Services:

As indicated in Table 16, in terms of agricultural extension services, those who had accessed/gotten extensions on improved crop management practices, livestock production, and natural resource management practices were 76.88%, 54.38%, and 61.25% respectively. This

result implies that extension services are more focused on crop production than natural resource management and livestock production that should have been important as well.

Table 16: Summary of extension services

Types of extension services (N=160)	N	%HHs
Extension of improved crop management	123	76.88
Extension of improved livestock production	87	54.38
Extension of improved NRM practices	98	61.25

Source: Survey result, 2021.

Climate Change/ Variability Related Problems:

It is a fact that climate change/variability affected farmers' livelihood. Many associated problems can be mentioned, the major ones encountered by the respondents were drought, too much rain, delay of belg season, high temperature, severe frost, heavy flood, outbreak grasshopper, outbreak pests, and diseases (Table 17).

Table 17: Summary of consequences of climate change/variability

Types of disaster (n =160)	N	%HHs
Drought or lack of rainfall	48	30.00
Too much rain	80	50.00
Erratic rainfall	69	43.13
Delay of belg season	43	26.88
High temperature	28	17.50
Severe frost	28	17.50
Heavy Flood	19	11.88
Outbreak of grasshopper	112	70.00
Outbreak of armyworm (temch)	58	36.25
The outbreak of other pests	25	15.63
Outbreak of disease/livestock	46	28.75
The proliferation of invasive weeds	9	5.63

Source: Survey result, 2021

Potential Drivers of Change in the Farming System:

The farming system has changed in the study area. These changes are derived by the potential factors like the use of improved varieties to increase production and productivity as the local variety which had been on the farmers hand could not withstand diseases as a result of climate change/variability, increasing crop mix over time in fear of risk related to loss of harvest from single crop item, decrease of livestock resource over time, shift from livestock to crop production to sustain food security as the land is fragmented due to population pressure and due to increasing prices of food items, disappearance of older varieties and substitution by the new ones, increased influence of crop and livestock diseases due to stress of heat and other factors, decline of land ownership, establishment of farmers based associations or cooperatives, expansion of towns as with the case of urban agriculture, introduction of cluster farming by the government to encourage agricultural commercialization and establishment of agro-processing industries. These issues in combination with government policies changed the way farmers used to produce crops and rear livestock (Source: KII and FGD).

Coping and Adaptation Strategies Being Followed by the Farmers

Coping and adaptation strategies of farmers as a response to climate change and variability are indicated below in Table 18. The top four coping mechanisms were buying food when the stored crop item runs out, selling livestock as the livestock resources are major assets to convert to cash in need of money for the purchase of input and other social-related issues, eating fewer meals per day to accommodate the amount for every member of the household and storing the grain for future with 55.00%, 53.13%, 48.75 and 43.13% respectively. The top four adaptation strategies being followed by the farmers were adjusting planting date in case of rain delay, changing crop varieties, decreasing the number of livestock, and planting grasses with 59.38%, 55.00%, 54.38%, and 50.00% respectively.

Table 18: Coping and adaptation strategies of respondents

Coping mechanism(N=160)	N	%HHs	adaptation strategies	N	%
Sold livestock	85	53.13	Change crop type	86	53.75
Rent out/ share out land	47	29.38	Change crop varieties	88	55.00
Borrowed money from friends or relatives	20	12.50	Change animal breeds	77	48.13
Borrowed money from OMO, coops, banks	24	15.00	Adjust planting date	95	59.38
Credit from traders and private money	20	12.50	Decrease livestock owned	87	54.38
Received food aid	10	6.25	Engage in beekeeping	38	23.75
Bought food	88	55.00	Plant trees	57	35.63
Ate less amount/ less meals per day	78	48.75	Planting grasses	80	50.00
Sought off-farm employment	42	26.25	Increase cultivable land	70	43.75
Grain storage/save grain for future	69	43.13	Engage in off -farm activity	42	26.25
Migrate to towns temporarily	-	-	Engage on irrigation	45	28.13
Send children for a housemaid	11	6.88	Water harvesting	40	25.00
Early marriage for girls	11	6.88	Got remittance	32	20.00
Give children for adoption	10	6.25	Take credit for inputs & improved farming	15	9.38
			Diversifying animal herds and selecting hardier breeds	40	25.00

Source: Survey result, 2021

Responses of the Farming Systems to Existing Agriculture-Related Policy Directions

The farmers in Atoti Ulo woreda started to work on a cluster farming system for maize which is the clear effect of government policy on the way farmers used to produce crops on fragmented land areas which cannot ensure their food security let alone supply marketed surplus. Associated response in farming system agriculture-related policy directions observed in that area was the new trend of using mechanization/tractors instead of manual labor, especially during the first round of land preparation.

Women's Participation in Agriculture and Benefit from Agriculture

To highlight the gender issues, secondary information taking Halaba as a case was shown below in Table 19. According to Messay (2012) in terms of land ownership in the Halaba farm community, men farmers' land ownership comes from different sources: male farmers have got 66.1% of land when they got married. This was through heritage 27.1%, 5.93% allocation, and 0.86% from leasing private farmers which clearly shows male dominance in control of resources. In terms of participation, men and women have different levels of participation in gender roles in various agricultural activities; such as level participation in cereal production for consumption.

Women had low access to improved agricultural inputs (fertilizer, improved seed, and insect pesticides) as compared to male partners. Women's participation in agricultural extension service is 9% and access to farmers' training ranges from 20.3% to 29% This is an indication of the low benefits of women in the agriculture sector.

Table 19: Summary of participation in agricultural activities

activities	Household members			
	Men	Women	Boys	Girls
ploughing	91.8%	0%	8.2%	0%
Sowing	96.6%	0%	3.4%	0%
Weeding	44.9%	21.8%	33.3%	0%
Activity	Household members			
	Men	Boy	Women	Girls
Cereal crop production	71.1	12.4	15.3	1.2
Cash crop production	7.2	4.8	69.5	18.5
Livestock production	16.7	58.7	58.7	b 4.6
Apiculture production	92.5		7.5	-
Poultry production				100
Daily working hours	9:30 (39.6 %) of 24 daily hours	-	14:30 (60.4%) of 24 daily hours	-

NB: Most of the daily working hours are imposed on women which means women are spending a significant of time on unpaid domestic and agricultural activities. Source: Review of literature, 2021

CONCLUSION AND RECOMMENDATIONS

Conclusion

The Major means of livelihood were crop cultivation (98.44%) followed by animal rearing (93.75%) in highland and crop accounts for 94.79% and animal rearing covers 91.67% in midland areas. The Major identified farming systems were Enset and barley Based mixed farming system, Maize based mixed farming system, Coffee based mixed farming system, Agro-pastoral farming system, and Chat and enset based mixed farming systems. The major crops in the study area were maize, common bean, finger millet, teff, potato, coffee, barley, and enset. The major livestock resources were cattle, chickens, sheep, goats, and donkeys. According to the respondents, 48(30%) had physical soil and water conservation structures on their farmland.

The farming system in the study area has shown dynamism due to drivers like the use of improved varieties, the decrease of livestock resources over time, diminish in grazing areas, shifts in livestock to crop production, the disappearance of older varieties, decline of land ownership, establishment of farmers-based associations, expansion of towns, the establishment of agro-processing industries, and production and productivity-related government policies like cluster farming.

Responses of the farming systems to existing agriculture-related policy directions include the introduction of mechanization and cluster farming in the Halaba zone from the study area. Secondary information indicates despite their participation in agricultural activities, the critical factor of production, the land is given to a male by their parents when they got married and women are neglected and had low access to improved agricultural inputs. Major coping mechanisms to climate change include selling livestock, buying food, eating fewer meals, and

storing grain for the future. Major adaptation strategies include adjusting planting date, changing crop varieties, decreasing livestock owned, and changing crop type.

The major constraints in crop production were low availability of improved or hybrid seeds, increase in the price of agricultural inputs, delay of the inputs at the required time, variability in the type of crop varieties, erratic nature of rainfall, and shortage of farm implements and labor. Market-related problems were inadequate market infrastructure, lack of market information system, lack of processing units, lack of proper modern storage facility, and price.

Livestock production constraints were prevalence of livestock diseases, shortage of feed, biological limitation of indigenous breeds of animals, shortage of water inadequate, accessibility of veterinary services, deficiency of vaccine and vaccine set-up, and limited availability of quality breeding purpose bulls. Marketing-related problems were inadequate availability of credit, poor access to organized markets, absence of a market information system, and unregulated trading. Natural resource management constraints were declining soil fertility, soil erosion and loss of topsoil, drought, land shortage, deforestation, soil acidity, and lack of adequate knowledge on natural resource management practices.

Recommendations

Improving crop and livestock productivity in the study area, improving access to improved varieties and breed at the required time, working to equip farmers' awareness on the livestock disease and improved crop management practices, and working to improve the marketing market information delivery, market infrastructure and pricing strategy is important. There is a need to work on post-harvest management practices to minimize the loss of crops from weevils and other pests. In areas of natural resource management, expanding soil and water conservation and gearing attention to maintaining the already constructed ones should be worked on. There is a need to work on improving women's access to agricultural extension services by focusing on relatively penetrable sub-sectors like poultry and garden vegetables in research and development works.

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