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Characterization and Analysis of Farming System in Guji Zone, Southern Oromia, Ethiopia

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ABSTRACT

This activity aimed at identifying and characterizing farming systems with possible intervention mechanisms for identified farming component in the study area. Data was collected from 257 households selected from three agro ecologies. Two major farming typologies of Pastoral/Agro pastoral and Crop-Livestock mixed farming were identified and further classified based on the major crop grown belt. Identified crop production constraints of the area were Lack of diversified alternative improved varieties adapted to different agro-ecologies, Lack of integrated crop and pest management technologies, Lack of alternative seed sources (seed producer cooperatives and private seed producers), insufficient knowledge on post-harvest handling. inadequate adoption of improved breeds, the lack and poor quality of available feed resources, and the traditional management approach the zone's main livestock production restrictions were found to be emerging illnesses and a lack of skills and knowledge regarding the deployment of better livestock technologies. Other significant production constraints that affect farmers' livelihoods in the midland areas include deforestation and soil erosion with the expansion of eucalyptus, frequent drought and depletion of soil fertility due to land degradation and termites in lowland areas, and soil acidity in highland areas caused by heavy rainfall. Therefore, improving the production and productivity of crops through the supply of improved inputs capacitates farmers' awareness of crop management and marketing linkage and Access to improved breed, improved forage, and livestock management intervention should availed for the area in addition to natural resource management.

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INTRODUCTION

According to Garnett et al. (2013), Atnaf et al. (2015), Sahle et al. (2018), and Kifle et al. (2020), a farming system is a distinct and reasonably stable arrangement enterprise that a household manages in accordance with well-defined practices in response to the physical, biological, and socio-economic environment and following the household goals, preferences, and resources. The combination of these activities is determined by the farmer's management abilities, resource endowment, and environmental conditions. Outlining viable development plans for farming systems requires an understanding of how the many components of the system are interdependent and how to balance the complex collection of farmer goals (FAO, 2016).

Low land degradation, low technological inputs, low soil fertility, weak institution linkage, and a lack of appropriate and effective agricultural policies and strategies have all contributed to Ethiopian agriculture's low productivity. This is because the farming system's dynamics are more focused on substance production than market-oriented productions. To address these issues and improve agricultural, livestock, and natural resource productivity, farming systems must be characterized and analyzed (Aklilu, 2015; Abush et al., 2011).

LITERATURE REVIEW

The underlying premise of the farming systems research approach is that individual farm operations that are categorized among several stakeholder groups are the best targets for on-farm issue solving. Production and returns could be increased by both established and developing technologies (Giller, K. E. et al. 2014). Researching a particular area's farming system is crucial to suggesting suitable technology to farmers. In order to map farming system typology, identify and characterize farming systems, and identify production constraints and opportunities for additional zone interventions, it also assists a biological researcher in designing environmentally friendly agricultural technologies that address problem-solving and are appropriate.

METHODOLOGY

An Explanation of the Study Area

The zone astronomically lies between 5o 00′ N to 6o 00′N and 39o 00′ E to 40o 00′ E. It is characterized by highland (40%), midland (26.67%), and lowland (33.33%) with different topographical features. Its typical annual rainfall falls between 526.75 mm and 2200 mm, and its elevation ranges from 1370 to 2900 meters above sea level. May through September is the primary rainy season; September through October is the second season.

Sampling Techniques

To choose responders, a multi-stage sampling technique was used. Five districts were purposefully chosen for the first stage: Bore, Ana Sora, Arda Jila Mea Boko, Adola Rede, and Odo Shakisso. Twelve kebeles were purposefully chosen for the second stage, five of which were from the highlands, four from the midlands, and three from the lowlands. Based on the secondary data of a total population of 192,121, of which 72755 highland, 72513 midland and 44853 lowland totals of 257 households were finally selected by (Yamane, 1967) using

0.062 margin of error (CSA, 2014; Habte et al., 2022; Tekle and Tesfu (2023). Probability proportional to sample size was used to locate samples across the three strata.

$$n = \frac{N}{1+N(e^2)}, \quad n = \frac{N}{1+N(e^2)}, N = 192{,}121, e = 0.062, \frac{192{,}121}{1+192{,}121(0.062^2)} = 257$$

Data and Analysis Method

We used both primary and secondary data. Key informants and the sampled households provided the primary data. Using PRA techniques, a targeted group discussion was conducted in order to gather preliminary qualitative data. A total of 3 farmers' FGDs were held within each cluster containing twelve group members who were systematically selected based on their agricultural experience, gender, educational background, etc. Three specialists from each district-one for each crop, one for each animal, and one for each natural resource-were consulted at every level about crop agriculture, livestock, and natural resource management. Lastly, 257 sample households provided household-level data. Data acquired from FDG were evaluated qualitatively, and summary statistics were used to analyze quantitative data. Constraints were prioritized using pairwise ranking.

RESULTS AND DISCUSSION

Socioeconomic Characteristics and Resource Ownership of Households

The average household head was about 37 years old, and the majority had a college degree. On average, each home had over eight family members, with a standard deviation of 4.28. It was discovered that there were 4.3 and 3.79 male and female family members per household, respectively (Table 1). The average number of livestock owned by each family in TLU was 3.22.

Table 1. Summary Statistics of Sample Farm Households Demography

Variable	Mean	Std. Dev.
Age	37	12.15
Family Size	8.14	4.28
Male Family	4.3	2.38
Female Family	3.79	2.48
Adult Mean Equivalent	6.73	3.49
TLU	3.22	2.02

The average amount of the cultivated land was 2.3 ha, and the average landholding of households was 4.27 ha. With a mean of 2.26 hectares, 2.30 hectares, and 0.75 hectares, respectively, cultivated land, grazing land, and community land make up the largest percentage of the land use pattern. The mean of 0.55 is due to forest land. Just around 1% of households own less than one hectare of land, whilst the majority (62% of households) own more than five hectares of land. Generally speaking, almost 90% of households own more than two hectares of land (Table 2).

Table 2. Landholding Distribution by Household

Range of Holding	Holders Percent	Mean	Stdev
Total land	257	4.27	3.58
Grazing land	257	0.75	0.45
Forest land	257	0.55	0.3
Communal land	257	2.26	0.63
Cultivated land	257	2.3	2.26
Less 1 ha	1	0.081	0.22
Between 1 and 2 ha	7	0.7	0.72
Between 2 and 5 ha	30	3.1	0.81
Above 5ha	62	6.4	6.51

The respondents' perceptions of the strength of extension services provided by various organizations were evaluated, and the majority of respondents felt that the service was very poor because it was heavily biased toward aspects of crop production, weak toward livestock production, and virtually non-existent in natural resource management (Table 3). Tamirat et al. (2019) and Kifle et al. (2020) reported a similar outcome.

Table 3. Extension Service Provision Rate

Rate Service	Crop Production		Livestock Production		Natural Resource Management	
Strong	Frequency	Per cent	Frequency	Per cent	Frequency	Per cent
	98	60.87	10	6.2	7	4.35
Weak	52	32.3	76	47.2	16	9.94
Very weak	21	13.04	75	46.6	138	85.7
Total	161	100	161	100	161	100

Guji Zone Farming System Typologies

Five sub-farming clusters were identified based on the region's crop production: the Highland cereal crop and rain-fed vegetable belt, the Maize-Teff-haricot bean belt, the Wheat-Teff belt, irrigation-based farming, and coffee-Chat farming. The two rain-fed cropping seasons of maize-tef and wheat-tef farming clusters include the majority of barley root crops (Figure 1). According to Birhanu and Azage (2006), crop genetic improvement that increases production and productivity can be achieved by crop specification in their particular agroecologist.

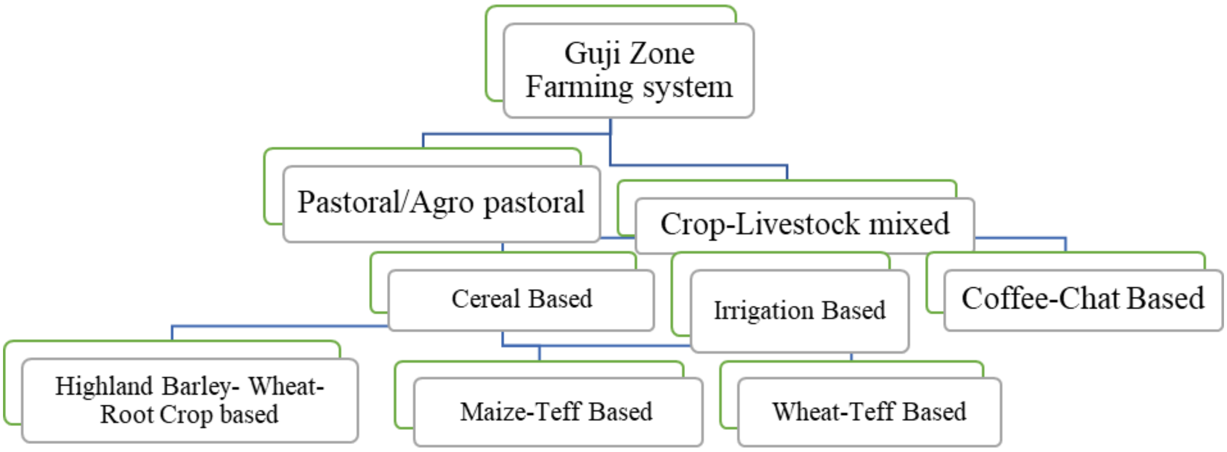

Figure 1. Broad Hierarchal Classification of Farming System Typologies in Guji Zone

Barley-Vegetables-Based Farming System

Barley, wheat, rain-fed root tubers, and crops like potatoes were the main crop kinds in these sub-clusters. This farming style produces pulses including faba beans and field peas, as well as head cabbage, shallot, and local cabbages. With 58.3% of the total land allocation, potatoes are the most advantageous sub-enterprise in this sub-cluster. Barley (food and malt) is grown on approximately 18.6% of the total land, followed by head cabbage, wheat, faba bean, and Enset, which each occupy 16.5%, 13.6%, 11.5%, and 6.5% of the land, respectively. There is a strong potential for potato production in this region, as evidenced by the mean productivity of 22 tons of potatoes per hectare, which is higher than the national average output (Table 4). In addition, highland fruits like apples and vegetables including Enset, shallot, and native cabbage were discovered. Additionally, the most significant businesses in this sub-cluster farming system were beekeeping, dairy production, sheep, and cattle husbandry.

Table 4. Major Crops Grown, Area Coverage and Production Share in Sub-Cluster

Crop	Area(ha)	Production (in ton)	Area coverage (%)	Production in (%)
Wheat	52.97	415	13.6	10.9
Barley	72.3	821.5	18.6	21.5
potato	101	2222	26.0	58.3
Head Cabbage	64	288	16.5	7.6
Faba bean	44.7	50.45	11.5	1.3
Field Pea	9.275	5.62	2.4	0.1
Enset	25	9.5	6.4	0.2
shallot	12	*	3.1	*
local cabbage	7	*	1.8	*

Total	388.245	3812.07	100.0	100

In general, about eleven production constraints of this sub-cluster were identified by farmers and they were ranked according to their importance (Table 4). In root-crop production, the major constraint was mentioned to be storage and market related. The perishability nature of the crop and lack of storage or processing technologies lead the producers to sell their produce at unreasonably lower prices during peak production seasons and huge postharvest losses (Table 5).

Table 5. Major Crop Production Constraints in Barely-Root Crops Based Sub Farming System

Constraints	**Score in pairwise ranking**	**Rank**
Soil acidity	12	1
Erratic rainfall	8	4
Frost	6	6
invasive grass weed	10	3
Disease	10	3
Insects	7	5
High-cost input price	12	1
Absence of seed suppliers	11	2
Lack of mechanization technologies	5	7
Soil fertility decrease	4	8
Perishability and lack of storage facilities for vegetables (root crops)	6	6

Maize-Teff-Based Farming System

The most profitable sub business in this sub-cluster is maize, which occupies around 85.7% of the total land allotment (71.1%) and is cultivated on approximately 9.4% of the total land, with head haricot beans coming in second with 9.4% and 9.6%, respectively. The mean productivity of maize was 5.8 quintals per hectare which is very low resulting of recurrent drought and other production constraints during the 2021/2022 production year (Table 6).

Table 6. Major Crops Grown, Area Coverage and Production Share in Sub-Cluster

Crop	**Area In (Ha)**	**Production In(Ton)**	**Area Coverage In (%)**	**Production Share In (%)**
Maize	348.25	1352.603(3.884)	85.7	71.1
Tef	38.375	38.9 (1.01)	9.4	13.6
Haricot bean	19.625	43.45 (1.47)	4.8	15.2
Total	406.25	13608.38	100	100

Recurrent drought, weed, insect pest (maize borer), low soil fertility (natural resource degradation), Lack of improved seed for all crop types (with haricot beans virtually nonexistent), high prices for various chemicals relative to land productivity and output prices, a lack of chemical supply, illegal chemical marketing where private traders set exorbitant prices, and the provision of either outdated or incorrect chemicals (Table 7). Based on the information obtained from CSA (2016) the crop production above the national yield of maize 3.7 tons/ha, teff 11 tons/ha and haricot bean 1.47 tons/ha respectively.

Table 7. Major Crop Maize-Tef-Based Sub-Cluster Farming System

Constraints	**Score in the Pairwise Ranking**	**Rank**
Recurrent drought	12	1
weed	11	2
insect pest	10	3
root crop disease (rust, blight, root rot)	8	5
Seed-related problems (type and amount)	12	1
Low soil fertility (NR degradation	11	2
Absence of seed suppliers	12	1
Week extension service (technical aspects)	9	4
Absence of agricultural mechanization	6	7
Lack of chemicals	7	6

Wheat-Teff Based Sub-Cluster of Farming System

Due to changes in the timing and severity of the rains, wheat and teff were taking over this region, causing businesses to switch from growing wheat and pulse crops to tef. Lack of improved seed for all crop types (which results in low tef production), high chemical prices relative to land productivity and output prices, a lack of chemical supply, black marketing of chemicals, where private traders set exorbitant prices, and the supply of either expired or incorrect chemicals (Table 8). Tamirat et al. (2019) reported a similar finding.

Table 8. Major Crop Wheat-Tef-Based Sub Farming System

Constraints	**Score in the Pairwise Ranking**	**Rank**
recurrent drought	12	1
Mono-cropping	5	6
Crop diseases (Wheat rust, wilt etc.)	11	2
Seed-related problems (type and amount)	8	4
Low soil fertility (NR degradation)	9	3
Invasive weed	7	5
Chemical related (High prices, supply gap)	12	1

Week extension service (technical aspects)	8	4
termite	7	5
insect pests (haricot bean)	11	2

Chat-Based Sub-Cluster Farming System for Coffee

This sub-cluster farming system is found in the Adola Rede, Shakiso, Girja and Wadera districts. The major coffee production constraints were categorized into two major groups by the farmers production side and harvest and postharvest handling and market-related constraints. From the production side, the entire traditional production system is the main one. Due to the lack of research and development intervention (support), coffee seed quality and productivity have not improved, production methods have not improved, and disease incidence is significant. However, there are no recognized ways of protection or treatment (no chemical or agronomic approaches). However, deforestation, which results in the loss of coffee shadows, poor soil fertility, and frequent drought were other significant limitations (Table 9).

Table 9. Major Production Constraints in Coffee-Khat-Based Farming System

Constraints	**Score in Pairwise Ranking**	**Rank**
Recurrent drought	12	1
Disease (CBD, CWD)	12	1
seedling shortage	11	2
Natural resource base(fertile soil and forest)	10	3
poor market and postharvest handling	9	4
low price	10	3
lack of Brand name (chat and coffee)	11	2
The high price of chemicals (chat and coffee)	8	5

Livestock Component

Cattle, sheep, goats, poultry, donkeys, horses, and bee hives are the main livestock species in the region (figure 2). The majority of the livestock species are native to the area and have adapted well to the agro-ecologies there. This suggests that the livestock production system is still at the subsistence level and is not focused on the market. Due to a variety of production limitations, a small percentage of exotic chickens and crossbred cattle have also been found to perform below expectations.

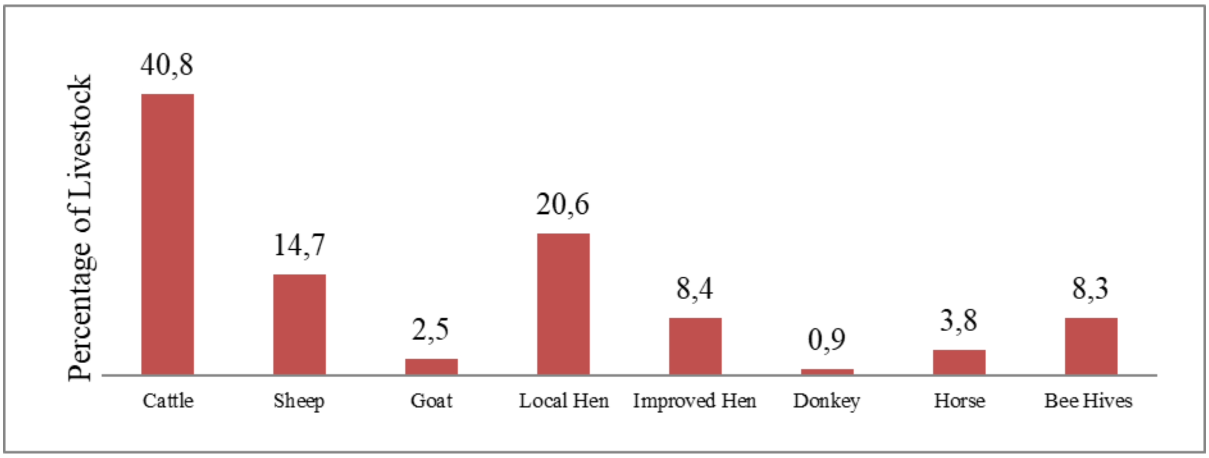

Figure 2. Livestock Resource in Guji Zone

Livestock Feed Resource

Four grazing strategies were used by livestock producers: crop leftovers, Enset sheath, communal land, self-grazing land, and mixtures of these. The majority of respondents used crop residue (tef, maize, barley, wheat, bean, and pea) extensively because their cattle found it tasty and they had no other choice for feed. The percentages of responders who used their own grazing land, community land, and enset were roughly 72%, 14%, and 8%, respectively. As a proof, the results showed that roughly 56% of respondents had been using enhanced forages, such as alfalfa, rhodes, and elephant, in little amounts (Table 10).

Table 10. Livestock Feed Sources and Feeding System of Respondents

Feed Resource	Frequency	Per Cent	Improved Forage		Per Cent
Enset	23	8.9	Adopt	yes	56
				no	201
communal	36	14.0	Forage type		
self-grazing land	185	72.0	Elephant grass	23	41.07
crop residue	13	4.7	Desho Grass and Rhodes	20	35.7
Total	257	100	Alfalfa	13	23.2

Livestock Production

Livestock production is a component of the traditional mixed crop-livestock production system, which has been shown to have poor production and reproduction performance and only provide the agricultural community with a subsistence level of income. According to reports, the average daily milk yield performance of local dairy cows was 1.2 liters, whereas upgraded cows produced 2.4 liters. Farmers were found to keep both native and developed poultry breeds. The household receives a portion of their monetary revenue from the sale of eggs and poultry. Nonetheless, one of the main factors influencing poultry performance is the availability of better and more appropriate breeds for the various agroecologies under the right management circumstances.

Another element of the system for producing animals was found to be the honey beekeeping industry. As per the survey results, the conventional hive is the most common type of hive, producing an average of only 3.38 kilograms of honey. In contrast, 56 transitional hives were evaluated, each producing 3.39 kilos of honey. According to Table 11, modern hives also produced 5.1 kilos of honey per hive. The yield of honey is, however, occasionally declining as a result of biological deforestation systems and the growing use of pesticides during the flowering season for crop management.

Table 11. Livestock Production

Entity	**Number**	**Livestock Production**		**Honey Harvesting Season**
		Sum	**Average**	
Traditional	252	852	3.38 (Kg)	the first season may
Transitional	56	190.	3.39(Kg)	second season December
Modern	57	219.	5.1(Kg)	
Improved cow	15	36	2.4 (liter)	
Local cow	256	306.	1.2(liter)	

Low performance of local animals, the high cost of the improved breed, farmers' lack of knowledge about better animal handling and management, and, lastly, the absence of a demonstration and multiplication site for better animal management practices were the issues that the Focal Group Discussion at both household status and animal production experts ranked during survey data collection. Aba Gorba (black leg), Aba sanga (faciolosis), sheep and goat python, and pneumonia for poultry are the main livestock illnesses that were found in the study locations (Table 12).

Table 12. Livestock Production Challenges

Challenges Livestock Production	**Number FDG**	**Rank**
low performance of local animal	12	1
The high price of improved breed	10	3
Lack of awareness of management and handling	11	2
lack of improved breed multiplication site	9	4
weather conditions for honey bee	9	4
chemical for crop management	8	4

Soil Fertility and Plant Nutrient Management

Fertilizer Used

One of the most important agricultural inputs for raising soil fertility and crop output is fertilizer. The majority of the zone's soil types respond well to fertilizer application, according to the farmers' experience. Fertilizer, which is mostly used for cereals, is typically the most commercial agricultural input. In the East Guji Zone, there is a cooperative union (CU) called Mea Boko Union, but it is not actively involved in fertilizer distribution and delivery. The union does not provide farmers with the agricultural inputs they require since it is very profit-oriented.

NPS, NPS + B (boron), NPS + Zn (zinc), and NPS + B + Zn are sources of N, P, S, and micronutrients (Zn and B), while urea has been utilized as a source of nitrogen. These novel fertilizer formulations were created based on the region's EthioSIS soil map. Farmers' experience showed that they do not apply fertilizer uniformly to all crops and soil types since the general recommended fertilizer rate does not account for variations in soil fertility within the locality. Farmers do not apply the same quantity of fertilizer to each type of soil because they believe that black and brown soils are more fertile than red and grey soils. Based on the experience of farmers, for crops grown on different soil types, fertilizer is applied based on their fertility status. Based on the survey results types of fertilizer used in the area are listed in (Table 13). A similar finding was reported by Tsegamariam and Tadele (2019) on soil conservation practices.

Table 13. Fertilizer Used in the Study Area

Fertilizer Type	**Frequency**	**Per Cent**
NPSBZn	14	5.4
NPS	83	32.3
NPSB	113	44.0
NPSZn	47	18.3
Total	257	100

Major fertilizer problems were identified and ranked by FDG and Experts in the study area in fertilizer application. Despite the promotion of integrated soil fertility management (ISFM) in the highlands, particularly in the Ana Sora district, there are currently no scientific recommendations for the rates at which inorganic and organic nutrient sources should be applied together. Despite the introduction of vermin compost in the research region, it was noted that the ISFM technique of applying compost or vermicompost + green manure was not implemented. Development and study so investigate the rate and suggest that the area is experiencing a burning problem (Table 14).

Table 14. Fertilizer Use Constraints

Problem	**Number**	**Rank**
Shortage of recommendations on fertilizer types and application rates	12	1
Application of sub-optimal fertilizer rates	10	3
Lack of awareness on the recommended time of nitrogen fertilizer (urea) application	11	2
Lack of access to fertilizer in terms of time and quantity	12	1
Distribution of substandard or poor qualities of new fertilizers	10	3
Distribution of fertilizer below the standard 50 kg bag weight	9	4

Farming System Dynamism

It was determined how respondents felt about altering the farming system. Due to a variety of circumstances, over 86% of all respondents said that their farming system has changed over the previous ten years. Of these, approximately 81.52% said that the change they saw was caused by low crop productivity, particularly in the highland areas, as a result of using local cultivars and a backward production system. Additionally, 76.54% said that the awareness, skill, and knowledge they gained from various bodies' extension services about the benefits of using production inputs in both livestock and cop production was the reason for the change in the farming system (Table 15).

Table 15. Farmer’s Perception of Changing Farming System

Change Dynamism	**% Respondents (yes)**
Perceived change in the farming system as a whole	86.20
Change in time of planting	47.60
Change in ways of production (crop management)	81.52
Change in ways of production (crop management)	48.87
Use of improved inputs (both crop and livestock)	76.54
Changing eucalyptus-dominated land use to crop production	11.23
Perceived change through government initiatives (wheat irrigation)	52.5

CONCLUSIONS AND RECOMMENDATIONS

Even though it has favourable agro ecology along with tremendous development efforts, the production and productivity of agriculture in the Guji zone remains below its potential. While livestock and natural resource technologies are typically absent, the availability of better agriculture technologies is largely insufficient, with technological transmission restricted to a small number of important cereal crops such as wheat, maize, and tef. The main obstacles to smallholder farmers' adoption of technology are high input costs, which include the scarcity and delayed delivery of agricultural supplies like fertilizer and better seeds. The issue is further made worse by restricted access to rural banking services. The main factors limiting productivity in the highlands are disease, insect pests, and soil acidity. The efforts to increase the output and productivity of important crops in midland and lowland regions are severely hampered by the severe problems of recurring drought and moisture stress.

In order of significance, the most significant obstacles to livestock production are the scarcity and low quality of feed supplies, the absence of better animal breeds, and the lack of knowledge and uptake of feed and dairy technologies.

The main issue in natural resources is land degradation from overgrazing, deforestation, and soil erosion, which lowers soil fertility and acidity and ultimately leads to low productivity and biodiversity loss in the research areas. Consequently, the provision of superior inputs increases agricultural productivity and production, increases farmers' knowledge of input recommendations, improves field management, especially integrated pest management (IPM) to reduce pests, and fortifies marketing ties. It is advised to increase awareness of the importance of physical and biological soil conservation for soil improvement and productivity, as well as to access improved breeds, improved forage, livestock management, disease infection control techniques, and improved marketing links.

FURTHER STUDY

This research still has limitations so further research is still needed on this topic.

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