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Research Article

Household Livelihoods and Economic Activities in the Birbo Watershed, Central Ethiopia

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Abstract

Baseline characterization is essential to measure project performance and impact evaluation before making many interventions to project processes. The main objective of the study was to investigate the socioeconomic characterization in the Birbo watershed. Both quantitative and qualitative data were used. Quantitative data were collected using a structured questionnaire with face-to-face interviews with households at the catchment site. One hundred twenty (120) households were selected randomly and interviewed. Major constraints and opportunities were identified by using key informant interviews and focus group discussions. The quantitative data analysis was carried out by using descriptive, inferential statistics and STATA software. Results of the study showed that the majority of the sample households (83%) were male-headed households. In the Birbo watershed mixed farming systems (crop and livestock raring) are the major (93%) occupation of the sampled households. According to the survey result, Wheat, Barley, Teff, Faba Bean, Field peas, and Potato are the major crops produced in the Birbo watershed, 91, 81, 83, 46, 30, and 19%, respectively. In terms of land degradation, the watershed is characterized by high land degradation caused by deforestation, overgrazing, continuous cultivation, and inappropriate cultivation. Low adoption of improved crops and livestock technologies is also the other problem identified in the watershed. Livestock feed shortage, no AI service, low adoption of improved forage, and low access to the cattle market were major problems in the watershed. Institution services such as training, extension advisory, field day, financial services (access to loans), and rural roads were other constraints in the watershed. Therefore, the study suggests that an integrated approach is more important and necessary for the sustainable use of watershed resources, and further development in all aspects of the watershed should be implemented. It is necessary to put appropriate rural land use policy by identifying proper land for specific purposes so that marginal and degraded lands are given urgent measures to recover and would not be put under cultivation. It is recommended to formulate strategies for sustainable management of the current study area and other areas with similar geographic settings.

Keywords

Baseline, Characterization, Constraints, Sampling Strategy, Socioeconomic, Birbo Watershed

1. Introduction

The history of watershed management in Ethiopia dates back to the 1970s with large watershed interventions [5]. The watershed approach to soil and water management aims to tackle severe land degradation, depletion of natural re-

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sources, inappropriate land use practices, low agricultural productivity, livestock feed shortages, inadequate integration of ecological and economic strategies, conflicts over communal lands, and limited stakeholder coordination. Despite these initiatives, many efforts have yielded unsatisfactory results due to limited community participation, low sense of ownership, impractical planning units, and failure to address local community needs [4, 13].

A watershed is more than a hydrological unit; it is a socio-political and ecological entity that plays a significant role in ensuring food security, social stability, and economic resilience for rural populations by delivering vital ecosystem services [7, 8]. Modern watershed development technologies are therefore not only focused on conserving natural resources but also on improving the socioeconomic well-being of communities that depend on these landscapes. However, the effectiveness of watershed interventions varies by location due to differing biophysical and socioeconomic conditions. This variation affects soil fertility, crop yields, water availability, and income-generating activities in the area [14, 17].

Although participatory watershed development has shown promising impacts in diversifying and enhancing livelihoods through soil and water conservation (SWC), these practices remain limited and unsustainable in the Birbo watershed. There is a noticeable decline in vegetation cover, forest area, grazing land, and soil fertility. Moreover, rapid population growth has increased demand for farmland, grazing land, firewood, and construction timber, accelerating deforestation and land degradation. Continuous cultivation and soil erosion have caused a significant decline in crop productivity [10, 1]. While many model watershed projects have shown positive outcomes, their sustainability is still questionable. Only about 35% of such projects have achieved favorable cost-benefit ratios [6]. Poor watershed characterization, inadequate planning, and weak implementation are among the primary reasons for underperformance. Hence, baseline characterization is essential for evaluating the effectiveness of interventions. Without accurate baseline data, it is impossible to measure progress or determine the impact of improvements. Since baseline assessments play a crucial role in understanding community living conditions and identifying strategies for livelihood transformation, these assessments provide the necessary foundation for project planning, implementation, and monitoring. A proper baseline helps identify key stakeholders, socioeconomic constraints, and collective opportunities for sustainable watershed development [3, 2]. Therefore, the objectives of this activity were to document the baseline socioeconomic characteristics of the Birbo watershed, identify key stakeholders, and establish a common understanding of the major socioeconomic constraints facing the community.

2. Methodology

2.1. Study Area Description

The study was undertaken in Birbo Watershed located in the Welmera District of West Showa Zone Oromia Region, Central Ethiopia (Figure 1). Geographically, the watershed is located at 9°0' - 9°02'30"N and 38°34' - 38°35'30"E with an area of 653.31 ha. It is about 30 km away west of Addis Ababa along the Ambo road. The district where the watershed is found is split into 2 agro-climatic zones namely highland (61%) and mid-highland (39%) with an altitude ranging from 2385 to 2925 m.a.s.l. This district receives an average annual rainfall of around 1100 mm [11].

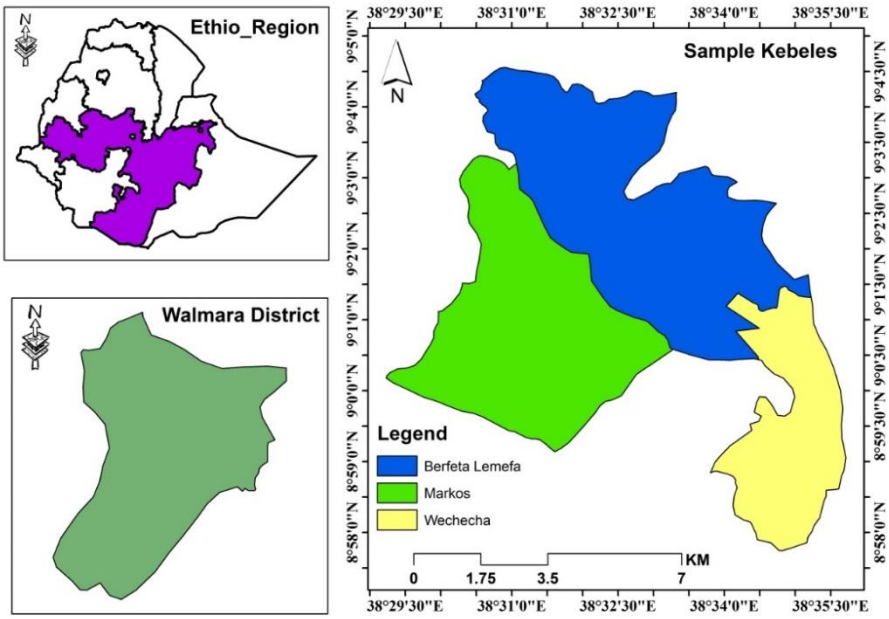

Figure 1. *Map of the study area.*

The area has a bimodal rainfall pattern namely, the "Belg" rainfall season (usually from December to April) and the "Meher" season (summer) which covers months from June to September accounting for more than 80% of the annual rainfall [12]. The average, maximum, and minimum annual temperatures of the area are 24, 27, and 0.1°C, respectively [12]. Crop-livestock mixed farming system characterizes agriculture in the district in which livestock in general and dairy production in particular contributes significantly to livelihoods. The major crops grown include wheat, barley faba bean, and teff (Eragrostis tef).

2.2. Data Type

Data were collected from the Birbo watershed sampling Kebeles on both primary and secondary levels. The data was gathered through a household (HH) survey, key informants interviews, and focus group discussions. From the sample frame designed by socioeconomics researchers, farmers were chosen at random. A simple random sampling technique was used to select the sample farmers.

2.3. Sampling and Data Collection

Key informant interviews and desk reviews were used to gather secondary data from the *District* and *Zone* experts. Furthermore, District and Zone officials, development agents, and other crucial organizations working on natural resource management in the Birbo watershed provided qualitative and quantitative primary data. To enrich and complement the primary and quantitative data, FGDs with 8 to 12 farmers in each Kebeles were also conducted utilizing a checklist. Youth, women, Kebele officials, and elders all contributed to the discussions. Quantitative data was gathered from soil and water conservation implementers using structured questionnaires and in-person interviews. To perform electronic data collection, the questionnaire for individual smallholder SWC implementers was put into the survey CSpro, program. The number of households among SWC implementers was calculated using the following sample size calculation formulas:

$$n = \left(\frac{(Z_{\alpha/2})^2 \sigma^2}{E^2}\right)$$

Where:

E = Tolerable margin of error;

α = Level of precision so that the estimates will be within the tolerable margin of error;

Z = value at specified level of confidence.

Considering α = 0.5, E=0.065, and Z=1.96, the sample size of the study was 120 households. This number was distributed to the three kebeles proportionally based on the number of households in each kebeles using CSA census data for 2021. Accordingly, 35 (29%) households from Wechecha, 45 (37%) households from Markos, and 40 (34%) households from Berfeta Lemefa kebeles were interviewed. Regarding, gender, males headed 83% of the respondents surveyed, while females headed 17%.

2.4. Data Analysis

Descriptive and inferential statistical analyses were conducted using STATA software. Descriptive statistics such as frequencies, means, standard deviations, ratios, and percentages were calculated for various variables to summarize and interpret the data. In addition to the structured questionnaire data, qualitative information gathered through key informant interviews and focus group discussions was used to enrich and complement the quantitative findings. This mixed-methods approach provided a more comprehensive understanding of the research issues under investigation.

3. Result and Discussions

3.1. Demographic Information of the Respondents

Out of the total 120 households interviewed in the Birbo watershed, 17% were female-headed. This finding shows that the involvement of female-headed households in agricultural activities within the catchment area is relatively limited (Table 1).

Table 1. *Demographic information of the respondents.*

	Kebeles				
Particulars	**Wechecha (n=35)**	**Markos (n=45)**	**Berfeta Lemefa (n=40)**	**Pooled (n=120)**	**P value**
Sex in%					
Male	83	84	82	83	
Female	17	16	18	17	

Particulars	Kebeles				
	Wechecha (n=35)	Markos (n=45)	Berfeta Lemefa (n=40)	Pooled (n=120)	P value
Age of the head in yrs. (mean)	41.9	47.3	42.2	44	0.213
Family size of the HH (mean)	5.9	5.8	5.8	5.9	0.651
Active labor force in the HH (mean)	2.6	2.5	2.5	2.5	0.927

The mean age of the survey households was 44 years. It was also observed that there was a high involvement of youth in soil and water conservation in the study area. The average family size was 5.9, and the mean active labor force was also 2.5 people. Thus, age, family size, and active labor size at the household level were the determinant factors regarding soil conservation technology adoption.

3.2. Socio Economics Status of the Respondents

Education: household decisions to adopt new technologies are significantly influenced by the level of education. Education plays a crucial role in increasing awareness and understanding of new technologies and their applications. In the Birbo watershed, the study found that most of the respondents had attained secondary education (grades 5-8), while a smaller portion had completed high school (grades 9-10).

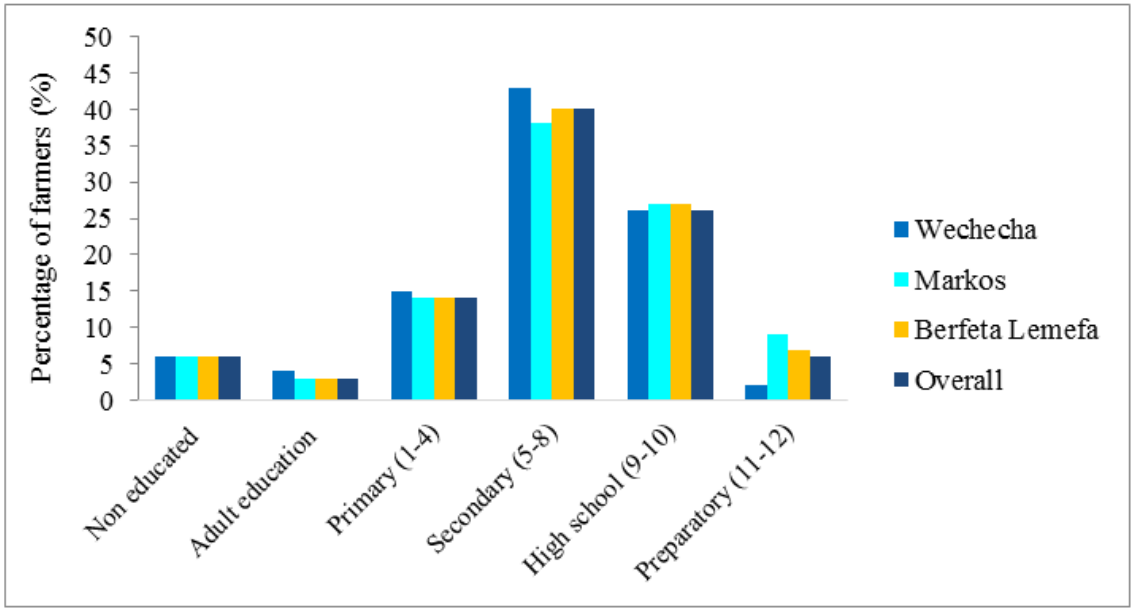

Figure 2. *Education status of the sampled respondents.*

Children's school attendance: in the Birbo watershed, the majority of school-going children are boys, with approximately 60% of male children attending elementary school, while only 40% are girls. This disparity suggests that girls are often overlooked or discouraged from pursuing formal education. This may be attributed to the significant role girls play in domestic responsibilities and agricultural labor, which often takes precedence over their schooling in the catchment area.

Wealth status: about wealth classification, more than half of the surveyed households fall under the "moderate" wealth category. The remaining respondents were categorized as "very poor," "poor," and a few as "better off," indicating socioeconomic diversity within the community.

Land ownership: the average landholding size per household was 1.10 hectares, with a standard deviation of 1.16 hectares. However, the average land area allocated specifically for irrigation-based agriculture was only 0.08 hectares. A statistically significant variation was observed in irrigation landholding among the three kebeles, primarily because only

two of them have access to irrigation infrastructure within the watershed.

Table 2. Land ownership of the respondents.

Land ownership in hectares	Wechecha n=35		Markos n=40		Berfeta Lemefa n=45		Overall n=120		P- value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Plot size (owned)	1.42	1.39	0.71	0.83	1.26	1.17	1.10	1.16	0.013***
Land allocated for perennial crops	0.03	0.07	0.07	0.21	0.11	0.47	0.07	0.31	0.469
Land allocated for irrigation	0	0	0.05	0.09	0.19	0.22	0.08	0.16	0.000***
Land allocated for grazing	0.19	0.51	0.08	0.21	0.10	0.20	0.12	0.32	0.227

Livestock Ownership: livestock production is a vital livelihood source and a key asset preservation strategy for rural households in the Birbo watershed. According to the survey, 96% of the sampled households own at least one type of livestock, with the majority rearing local breeds. This high rate of ownership highlights the significant role that livestock plays in sustaining household income, food security, and resilience against economic shocks.

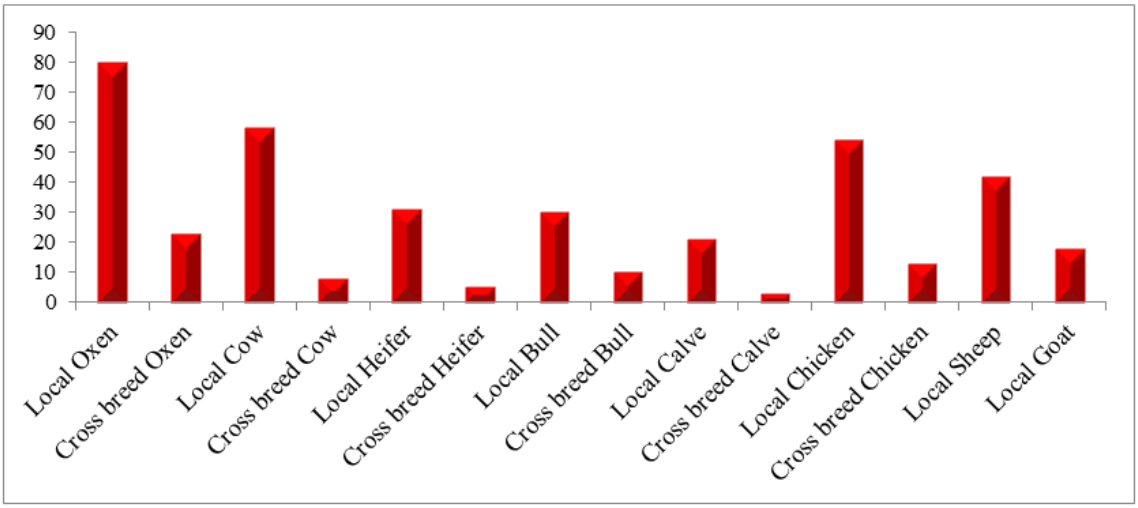

Figure 3. Livestock ownership if the households.

Household decision making and income sources: in the Birbo watershed, household income is generally managed by the head of the household. Income derived from salaried employment is primarily controlled by the spouse, whereas agricultural income tends to be managed by the household head. Additionally, income from non-agricultural businesses is also largely overseen by the spouse.

The primary sources of income for rural households in the watershed are farming and livestock rearing, accounting for 93% of the total. Furthermore, 45% of respondents generate income through the sale of fruits and vegetables. A smaller proportion about 5% earn income from pottery production (locally known as Shekila Sira), particularly among households residing in the lower part of the watershed.

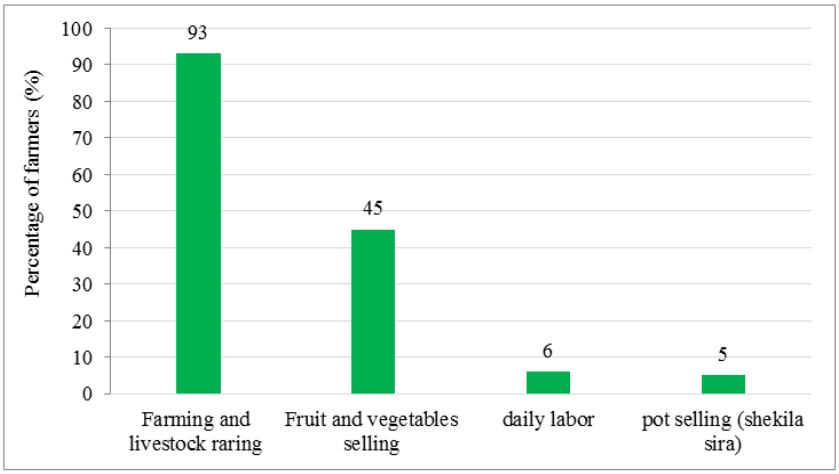

Figure 4. Major source of income of the households.

Household Food Security: food insecurity in Ethiopia is largely rooted in the heavy reliance on undiversified livelihoods, predominantly characterized by low-input, low-output rain-fed agriculture. Most smallholder farmers are unable to produce sufficient food even during years of favorable rainfall to meet their household consumption needs. This vulnerability is further exacerbated by a fragile natural resource base and unpredictable climatic conditions. Current policy approaches emphasizing agricultural intensification have proven to be inadequate, particularly in the absence of supportive institutional frameworks. Challenges such as rigid land tenure systems and ethnic federalism continue to reinforce unsustainable livelihoods. Additionally, poorly targeted food aid interventions have, in some cases, contributed to long-term dependency at both the household and national levels. In the context of the Birbo watershed, approximately 21% of households experience food shortages annually. These shortages are attributed to multiple factors, including crop diseases, pest infestations, and irregular rainfall patterns, all of which compound the already precarious food security situation in the area.

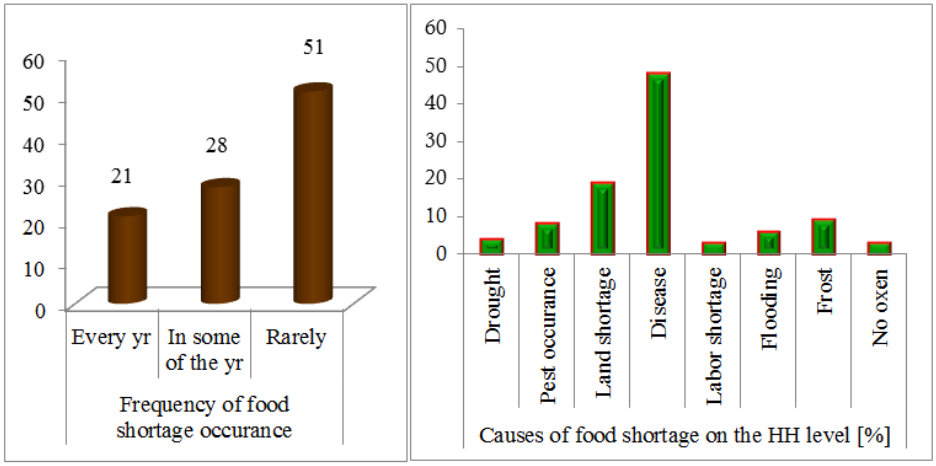

Figure 5. Household food security.

3.3. Farmers Perception on Land Degradation and SWC Practices

Local farmers in the Birbo watershed have a clear understanding of the land degradation challenges affecting their area. According to the findings from focus group discussions (FGDs), a significant portion of forest and bush land has been converted into cropland, often without the implementation of appropriate land management practices. Continuous cultivation without fallowing has been a common practice, further accelerating soil degradation. The majority of respondents (87%) acknowledged the presence of land degradation in the watershed. Among the primary causes identified, deforestation ranked highest (78%), followed by con-

tinuous cultivation (14%), overgrazing (6%), and inappropriate farming practices (2%). These findings suggest that increasing population pressure has driven local communities to convert forested areas into farmland to enhance household food security. This observation aligns with findings from similar studies, such as those by, [15, 9].

Table 3. Respondents' perception on land degradation and major causes of degradation.

Variables	Percent (%)
Land degradation (Yes)	87
Major causes of land degradation	
Deforestation	78
Continuous cultivation	14
Over grazing	6
inappropriate cultivation	2

3.3.1. Farmers' Experience of Soil and Water Conservation Practices

The mean soil and water conservation experience was 9.65 and this shows farmers are skilled and well experienced with soil and water conservation practices.

Table 4. SWC experiences of respondents.

Particulars	Wechecha n=35		Markos n=40		Berfeta Lemefa n=45		Overall n=120		P-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
SWC experience in years	6.74	6.69	11.73	10.84	9.85	6.22	9.65	8.6	0.2884

Source: Survey data, 2021

The survey results indicated that 62.8% of soil and water conservation (SWC) measures in the Birbo watershed were implemented on individual farmlands through community-based campaigns. The remaining 37.2% of SWC interventions were carried out on degraded communal lands within the catchment. Among the various conservation methods implemented, soil bunds were the most widely adopted, accounting for 90.4% of all practices. This was followed by tree plantations (5.9%) and check dams (3.7%). These findings highlight the community's strong engagement in soil bund construction, reflecting its perceived effectiveness in reducing soil erosion and improving land productivity.

Table 5. Type of SWC practiced applied in the study area.

Variables	Percent (%)
Soil and water conservation practices implemented on farmlands	62.8
SWC practices implemented on degraded land	37.2
Type of SWC practices implemented by farmers	
Soil bund	90.4
Check dam	3.7
Plantation	5.9

Source: Survey data 2021

3.3.2. Soil Erosion Type

As presented in Table 6, the dominant type of soil erosion observed in the Birbo watershed was rill erosion**,** reported by 72% of respondents. This was followed by sheet erosion**,** which accounted for 18%. Gully erosion was also identified as a significant problem, particularly in the upper and middle sections of the watershed where land degradation is more pronounced. Furthermore, the overall intensity of soil erosion was perceived to be high across the catchment, with

approximately 70% of respondents indicating severe erosion impacts. These findings underscore the urgent need for effective soil and water conservation interventions to mitigate land degradation in the area.

Table 6. Type of soil erosion and intensity in Birbo watershed.

Type of soil erosion	Percent (%)
Rill	72
Sheet	18
Gully	10
Soil erosion intensity	
Severe	70
Moderate	23
Slight	7

3.3.3. Soil Fertility Management

In response to the question regarding changes in soil fertility over time on their farmlands, 71% of respondents reported that soil fertility has been declining gradually. Conversely, 10% of respondents, who had implemented specific soil fertility management practices, indicated that their soil fertility had improved over time. To address declining fertility, farmers have taken several steps, including the use of chemical fertilizers (67%), as well as the implementation of soil and water conservation (SWC) measures and crop rotation practices. These strategies reflect farmers' awareness of soil degradation and their efforts to restore and sustain soil productivity on their lands.

Table 7. Trend of soil fertility in the watershed.

Trend of soil fertility in the watershed	Percent (%)
Decreasing	87
Increasing	10
No change	3
Mechanism of soil infertility management	
Using fertilizer	67
Implement SWC practices	16
Crop rotations	10
Others	7

3.3.4. Type of Fertilizer Farmers Used

The majority of households in the study area (68%) primarily relied on inorganic fertilizers for agricultural crop production. In contrast, 12% of respondents reported using organic fertilizers, including farmyard manure (FYM), compost, and vermicomposting. Organic fertilizers were particularly preferred for specific crops, such as potatoes and various irrigated crops cultivated within the catchment, due to their beneficial impact on soil health and crop quality.

Table 8. Fertilizer type respondents used.

Type of fertilizer farmers used	Percent (%)
Inorganic	68
Integrated	20
Organic	12
Type of organic fertilizer farmers used	
Farm yard manure (FYM)	81
Compost	16
Vermi-compost	3

3.4. Major Crops Production in Birbo Watershed

A variety of crops including cereals, oilseeds, and other staple food crops are cultivated in the Birbo watershed. Among the cereals, teff, barley, and wheat are the most commonly grown, while faba beans and field peas are also produced, though with relatively limited land coverage. In addition, potatoes, vegetables, and root crops are grown, particularly in the Markos and Berfeta Lemefa kebeles, where these crops are widely cultivated. However, crop productivity in the watershed has significantly declined due to the use of traditional farming practices, poor land management, intense soil erosion, and related environmental challenges. As a consequence, the area has been classified as food insecure, with much of the population dependent on food aid, particularly in years marked by crop failure.

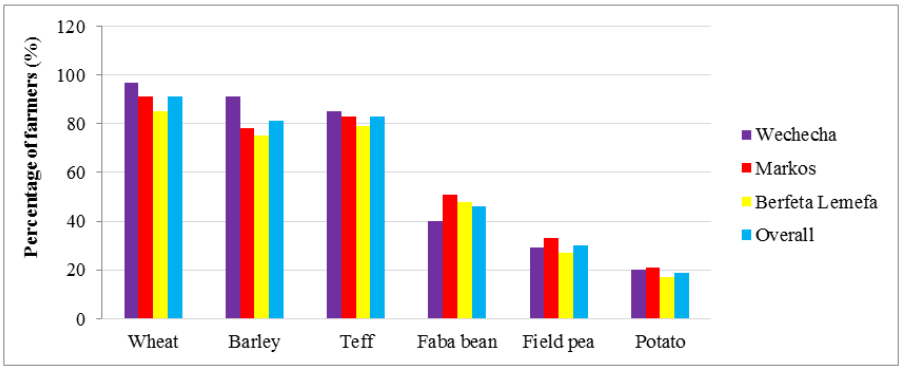

Figure 6. Major crops produced in the watershed.

Irrigation Access

Enhancing irrigation efficiency presents a vital opportunity for improving agricultural productivity and achieving food security in the Birbo watershed. Although irrigation practices have been in place for many years at various farm levels, the system remains inefficient and poorly managed. Key challenges include excessive water loss, limited awareness of efficient water use, the absence of local demonstration sites for irrigation utilization, and low adoption of modern irrigation technologies. As a result, flood irrigation remains the dominant method, used by approximately 98% of irrigation users. Only 2% of the respondents reported using basin irrigation, primarily in the Markos and Berfeta Lemefa kebeles. This highlights the urgent need for interventions aimed at improving irrigation practices, raising awareness, and promoting the adoption of efficient and sustainable irrigation technologies across the watershed.

3.5. Livestock Production in Birbo Watershed

3.5.1. Livestock Feed Shortage

The livestock sector plays a significant role in both economic and social development by contributing to food and nutritional security and supporting a productive and healthy lifestyle**.** In Ethiopia's smallholder agricultural systems, livestock serves as a vital resource for economic diversification and improving rural livelihoods. Despite the country's vast livestock population and genetic diversity, the sector's economic and nutritional contributions remain limited, largely due to the underutilization of its potential.

One of the primary constraints to livestock productivity in Ethiopia is the shortage of quality feed and fodder**.** Livestock requires a balanced and nutritious diet; however, the availability of high-quality feed remains a persistent challenge. Various studies have indicated that while Ethiopia possesses a rich and diverse pool of livestock resources, the sector's contribution to household income remains minimal. Survey findings reveal that feed costs account for over 50% of the total production and marketing expenses in livestock operations. To develop effective and market-oriented interventions**,** it is essential to assess as well as the management and utilization practices employed by livestock producers. In the context the types of feed resources available**,** of the Birbo watershed, feed scarcity has emerged as a major constraint**,** hampering efforts to enhance livestock productivity and improve the livelihoods of local communities.

Table 9. Livestock feed shortage in the catchment.

Feed shortage	Percent (%)
Yes, sometimes	43
Yes, serious problem	29
Not at all	28

3.5.2. Livestock Feed Type

Most households in the Birbo watershed primarily rely on feed sources such as crop residues, open-field grazing, green fodder, and byproducts from local beverages. These feed types are commonly used to sustain livestock throughout the year. Focus Group Discussions (FGDs) revealed that although agro-industrial byproducts such as oilseed cakes and bran are widely recognized as valuable livestock feed in many parts of the country, their use in the Birbo watershed remains limited. This is largely due to factors such as limited access, lack of awareness among farmers, and the high cost associated with these inputs. Grazing land within the watershed is generally poorly managed. Ownership patterns show that grazing lands are either under community or private control. The average land size allocated for grazing was found to be 0.12 hectares per household. In terms of productivity and management, private grazing lands performed better than communal ones. On private lands, livestock are often tethered, which allows for better control of grazing. In contrast, communal lands are subject to open grazing practices, which frequently lead to degradation. Several challenges affect both private and communal grazing areas. These include land scarcity, limited experience with haymaking and fodder con-

servation, competition with crop production for land use, and general overgrazing. Communal grazing areas are particularly vulnerable to misuse and degradation due to the lack of clear ownership and disputes over land access, especially among youth and landless community members. Furthermore, both types of grazing lands lack appropriate management interventions. There has been little to no effort to implement sustainable practices or improve the condition of these vital resources (Figure 7).

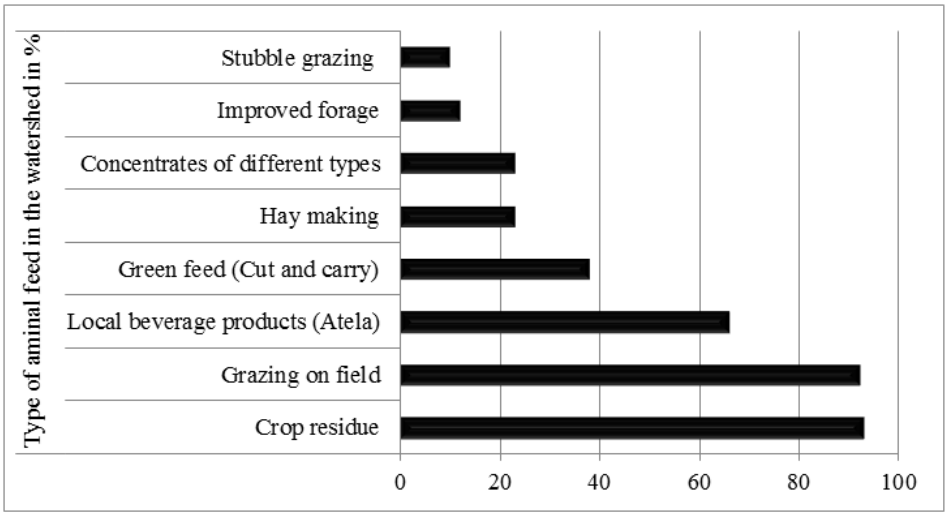

Figure 7. *Type of livestock feed dominated in the watershed.*

3.5.3. Improved Livestock Feed Adoption

Local farmers in the Birbo watershed rear cattle not only as a primary livelihood source but also as a means to diversify income and serve as a buffer against crop failure due to natural hazards. In addition to traditional practices, the adoption of improved cattle breeds and high-nutrient forages has shown the potential to enhance income from livestock production. Despite the efforts of various development partners to promote improved livestock feeding practices, adoption remains very low in the watershed. Only 5% of the respondents reported using improved forage varieties such as oat-vetch, while 4% adopted Sesbania sesban. The primary barriers to adoption identified by farmers include the high cost of inputs and limited access to improved forage seeds and technical support. These constraints have significantly hindered the widespread uptake of improved feeding practices in the area, thereby limiting the potential benefits for household income and livestock productivity.

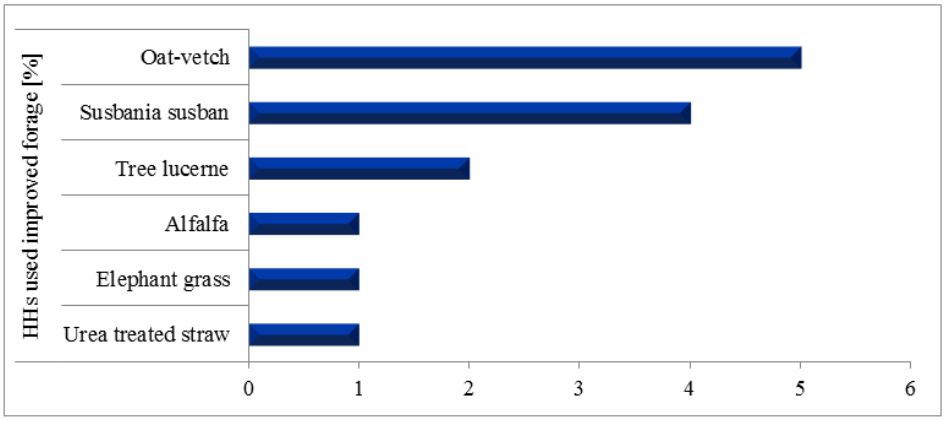

Figure 8. *Adoption status of improved forage.*

3.5.4. Livestock Disease

Livestock diseases have both direct and indirect impacts on human nutrition, community development, and sociocultural systems. Zoonotic and food-borne illnesses can reduce human productivity, diminish quality of life, and impose financial burdens due to treatment costs. However, in the Birbo watershed, livestock diseases are not considered a major concern. This is largely attributed to the routine animal vaccination programs conducted at regular intervals. As a result, only 8% of respondents identified livestock diseases as a significant issue in the area.

3.5.5. Artificial Insemination (AI) Service

Traditional livestock-rearing systems often prioritize maintaining a diverse range of livestock breeds within their herds. These breeds, developed in specific ecological and sociocultural environments, are uniquely adapted to survive the challenges of their surroundings. However, in the study area, farmers do not rely on formal records to assess cattle performance; instead, they base their breeding decisions on physical characteristics. The selection of animals for breeding is often determined by observable traits, with farmers choosing the best stock based on factors such as milk yield, growth rate, and reproductive health. The study found that natural mating is the most common breeding method within these herds, with bulls being sourced both from the farmers' herds and from neighboring farms. Despite this, respondents indicated that the insufficient availability of high-quality bulls often leads to negative selection, increasing the risk of inbreeding. Most farmers in the area prefer using bulls for breeding over artificial insemination (AI), mainly because AI services are either unavailable or irregular. The rearing of bulls plays a significant role in these communities, particularly when access to AI is limited. However, many farmers are hesitant to rear bulls, citing both a lack of awareness and economic concerns as barriers.

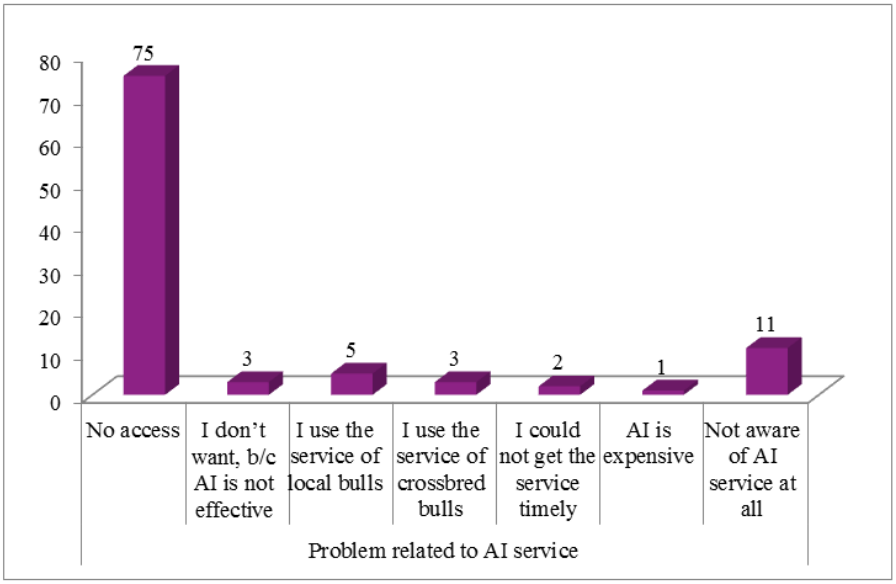

Figure 9. *Artificial insemination (AI) service.*

3.5.6. Fattening

Cattle fattening practices and meat consumption are typically on a small scale in the study area. Farmers often engage in fattening one or more cattle by tethering them and providing hand-fed feed. The majority of respondents (83%) preferred fattening oxen, while the remaining 13% favored fattening sheep. Meat consumption generally occurs during holidays or on regular market days when individuals purchase meat from butcheries. Others consume meat during various national and religious festivals through shared slaughtering events, such as "kircha." Respondents also reported practicing backyard slaughtering, which is largely due to the absence of formal slaughterhouse facilities and the lack of oversight from animal health and meat inspectors within the town municipality. This situation raises concerns from a public health perspective, particularly about zoonotic diseases, as the consumption of raw meat is common. During the fattening process, farmers adopt specific management practices to improve the cattle's condition. Animals selected for fattening are separated from the rest of the herd and provided with dedicated shelter, quality feed, and ample water. Their movement is restricted by tethering to prevent energy loss from searching for food and water. In some cases, underperforming cattle are kept for longer periods to reach the desired fattening target.

3.5.7. Cattle Market

Market participants in the cattle trade include producers, medium to large-scale traders, brokers, butchers, restaurant owners, and farmers purchasing cattle for replacement. In primary markets, the volume of animals sold is significantly higher compared to village-level sales, and these markets feed into terminal markets. However, the cattle markets lack basic facilities such as feeding, watering, housing, and weighing stations. Market information is essential for reducing uncertainties and bridging information gaps in the agricultural sector. A majority of respondents (89%) reported that they seek market information before selling cattle. Sources of this information include neighbors, friends, relatives, personal visits, radio broadcasts, and extension agents. Regarding pricing, cattle prices are largely determined through strong bargaining between buyers and sellers. In some cases, brokers are involved in price negotiations, but this often results in lower profit margins for producers due to the commission paid to the middlemen. The study identified several marketing channels for cattle: farmers sell to other farmers, consumers, traders, or butchers. Notably, 89% of respondents sold their cattle to traders, who then transport the cattle to terminal markets, such as the capital city, Addis Ababa. Cattle prices tend to rise during holidays, and this seasonal increase attracts traders from various regions, who purchase cattle and transport them to tertiary markets in preparation for festive seasons.

Table 10. Farmers preference of livestock for fattening.

Farmers prefer for fattening	Percent (%)
Oxen/ bull	83
Sheep	13
Goat	4

3.5.8. Source of Water for Livestock

Rivers serve as the primary water source for livestock, with over 90% of households relying on them for both livestock drinking and domestic use. Respondents reported year-round access to water, and water scarcity for livestock and domestic purposes is not a concern. Additionally, there are no issues with water pollution, as there are no factories, other than water-related facilities, in the area that could contaminate the water supply.

3.6. Climate and Weather Variability

Households in the sample Kelebes are facing significant concerns due to climate change and unpredictable weather patterns. The majority of respondents reported that climate change and weather variability such as droughts, seasonal fluctuations in rainfall and the impact of crop pests and diseases are negatively affecting their livelihoods. Similarly, livestock losses in the watershed have been linked to drought, animal diseases, and floods.

3.7. Institutional Services

3.7.1. Social Capital

Social capital refers to the network of relationships among individuals within a society, enabling it to function effectively. It involves interpersonal interactions, a shared sense of identity, mutual understanding, common norms and values, trust, collaboration, and reciprocity, all of which contribute to the smooth operation of social groups. Often considered an investment that yields public benefits for the common good, social capital plays a crucial role in the success of any organization. Ignoring its value can hinder progress and lead to inefficiency or even failure. In the watershed, farmers were found to be more engaged in informal forms of social capital, such as Edir and Ekub, rather than in more formal structures. These informal social networks played a significant role in supporting the agricultural farming system, contributing more substantially to its functioning.

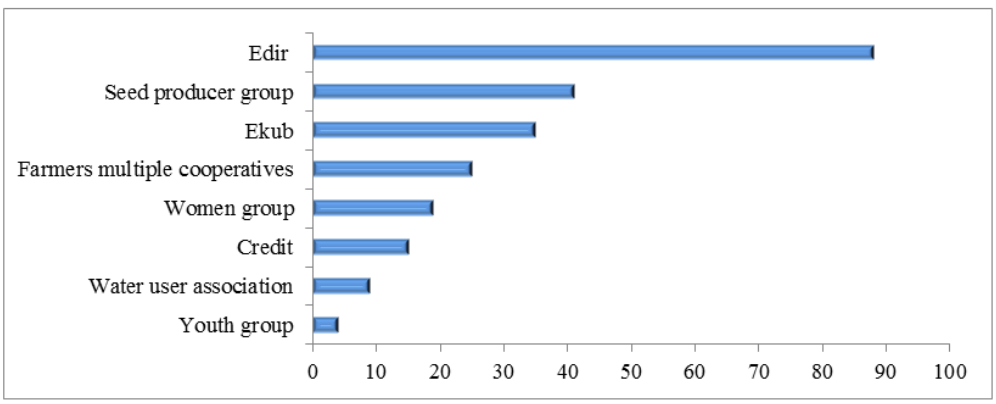

Figure 10. Farmers' participation in collective and social sectors.

3.7.2. Financial Accessibility and Saving

Access to finance refers to the ability of individuals or businesses to obtain financial services such as credit, deposits, payments, insurance, and other risk management tools. Limited access to finance is a major barrier to the widespread adoption of new agricultural technologies in the country. In the Birbo watershed, farmers, like those in other parts of the country, face poor access to loans, with only 8% of them having access to credit (Figure 11). The saving and borrowing habits of the households in the sample were also low. The primary sources of financing for farmers are relatives and microfinance organizations. Cooperatives typically provide in-kind loans, such as agricultural inputs. However, neither government nor commercial banks in the watershed offer credit to smallholder farmers. This observation aligns with finding from similar study, such as this by, [16].

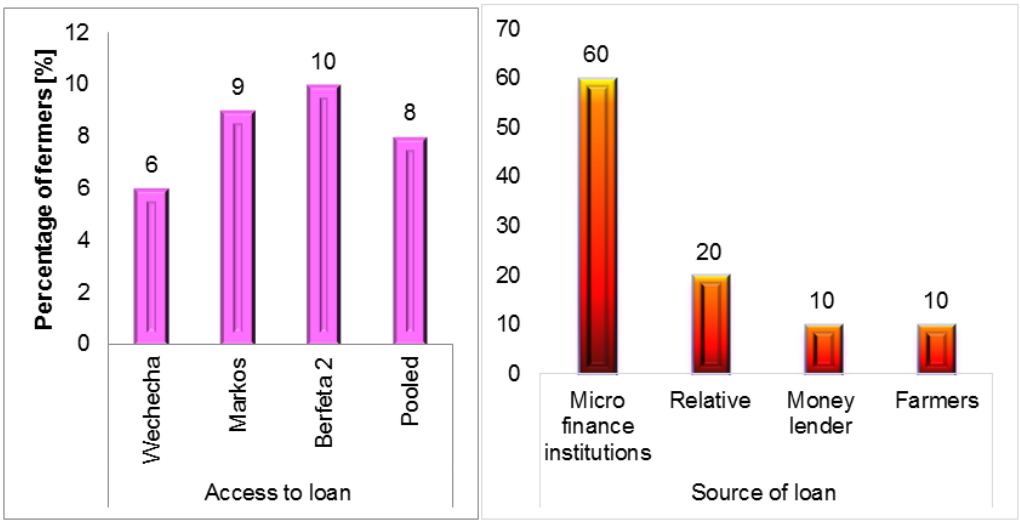

Figure 11. Respondents' access to loan and source of loan.

Households in the catchment area use loans to purchase agricultural inputs such as seeds, fertilizers, and pesticides, as well as for other purposes like livestock fattening and food purchases. However, only 1% of households use loans to invest in expanding their irrigation agriculture. These shows that households are hesitant to engage in irrigation farming, likely due to the limited focus on irrigation agriculture by both extension agents and the government in the watershed.

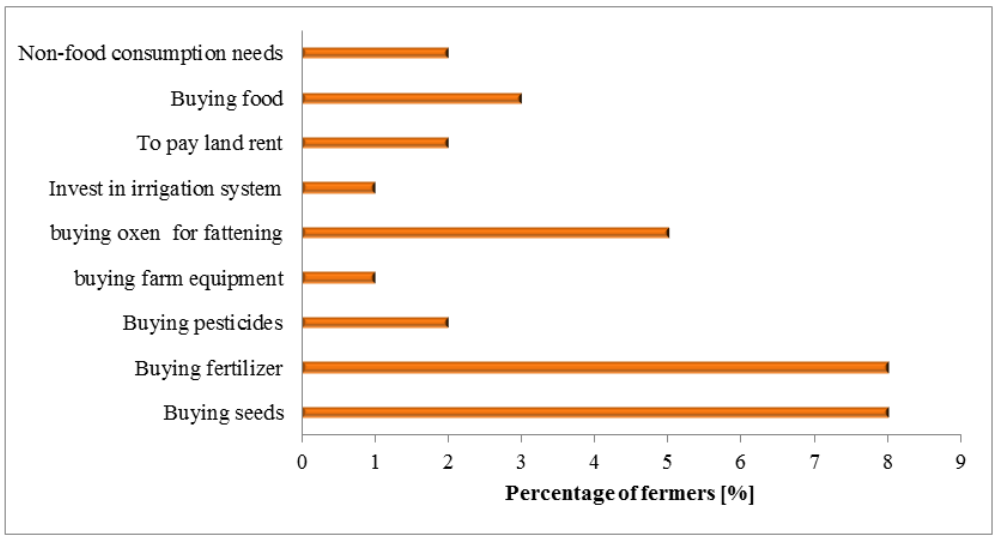

Figure 12. Farmers' purpose of loan in the watershed.

3.7.3. Training and Extension Services

In the Birbo watershed, various extension strategies and techniques have been employed to promote and disseminate improved agricultural technologies. Key approaches include training, extension services, demonstrations, and field days. According to the survey, 79% of farmers received extension advice on farmland management, crop cultivation, and livestock raring. Over the past three years, approximately 67% of farmers participated in demonstrations, and 59% received formal training in agricultural practices within the watershed. Additionally, 72% of households primarily received agricultural training from government extension services, followed by NGOs and research centers (Figure 13).

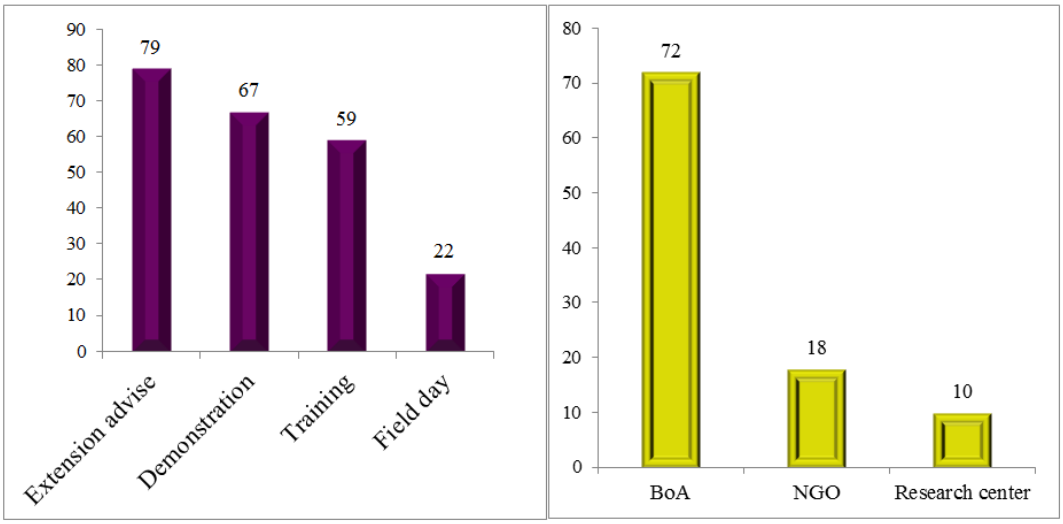

Figure 13. Extension services.

3.7.4. Health Institution in the Watershed

The availability and access to infrastructure are vital for rural communities, as they form the foundation for improving living standards. Beyond mere availability, the quality of infrastructure significantly impacts people's quality of life. Access to transport and markets is particularly important for boosting the confidence of both land-owning and landless households, enabling them to engage in income-generating activities that enhance their economic conditions. In the Birbo watershed, more than 81% of households have access to key facilities such as Farmer Training Centers (FTCs), health centers, and elementary schools. However, despite this access, only 67% of women in the watershed have access to child delivery services, with the remaining 33% giving birth at home with the assistance of traditional midwives.

Regarding energy sources, 83% of households reported having access to electricity, but primarily for lighting purposes. Only 8% of households used kerosene lamps (Kuraz), and 7% relied on burning wood. For cooking, the vast majority (96%) of households depend on fuel wood, typically gathered from nearby trees and natural forests. Due to the degradation of forest resources and limited access to fuel wood, many households have started planting various types of trees near their homes. Collecting fuel wood is primarily the responsibility of women, often with assistance from boys and girls.

Table 11. Source of energy at household level.

Farmers' source of energy for light	Percent (%)
Electricity	83
Fuel wood	7
Kerosene lamp	8
Solar	2
Source of energy for cooking	
Fuel wood	96
Cow dung	4
Who is responsible for fuel wood collection?	
Men	9
Women	56
Boys	15
Girls	20

3.8. The Major Potential and Constraints of Birbo Watershed

Potentials: The Birbo watershed is strategically located 30

kilometers from the capital city, Addis Ababa, which provides excellent road access for effective management and continuous monitoring. The watershed receives an average annual rainfall of around 1,100 mm, with a bimodal rainfall pattern, supporting diverse agricultural activities. The area's agricultural system is characterized by crop-livestock mixed farming, with livestock, especially dairy production, playing a significant role in local livelihoods. The watershed benefits from a reliable source of ground and surface water, including small tributaries that flow year-round. Additionally, the watershed offers a favorable environment for animal husbandry, including fattening, dairy production, and breeding. The presence of multiple ethnic groups further enriches the area with a wealth of indigenous knowledge, providing an opportunity for knowledge sharing and transfer.

Constraints:

a) Soil and Land Degradation: High-intensity rainfall and prolonged wet periods lead to significant soil erosion, resulting in land degradation due to heavy runoff during the rainy season.
b) Traditional Farming Systems: The communities primarily follow traditional farming practices with limited land management techniques, which hinder sustainable agricultural development.
c) Knowledge and Skill Gaps: There is a notable lack of expertise in maintaining soil and water conservation (SWC) practices, and watershed-based SWC activities are labor-intensive, making them difficult to sustain.
d) Deforestation: The expansion of agricultural land, charcoal production, fuel wood gathering, and construction activities contribute to significant deforestation in the region, particularly in natural forests.
e) Overgrazing and Poor Livestock Management: High livestock populations, coupled with inadequate forage and feed, result in overgrazing, livestock tracks, and soil compaction.
f) Soil Fertility Decline: Soil fertility issues are prevalent, affecting crop yields and the overall productivity of the land.
g) Declining Water Flow: Decreasing stream flow and challenges in managing irrigation water further exacerbate agricultural productivity issues.
h) Impact of Water Factory Expansion: The development of a water factory near the watershed and the perception of farmers regarding land degradation management pose additional challenges to the region's sustainable development.

4. Conclusion and Recommendations

The baseline socioeconomic characterization of the Birbo watershed provides valuable insights into the demographic and socioeconomic conditions, agricultural institutions, natural resources, crop and livestock production, as well as climate and weather patterns in the area. Institutional services, such as training, extension advisory services, field days, financial services (including access to loans), and rural road infrastructure, were identified as key constraints in the watershed. This information is essential for identifying the main issues related to natural resource conservation, as the baseline study aimed to assess potential changes in the economic, ecological, and social systems of the Birbo watershed. Key natural resource challenges identified include soil fertility decline, severe rill erosion, and a low adoption rate of soil and water conservation (SWC) technologies (only 16%). Additionally, many households rely heavily on inorganic fertilizers (67%) for soil fertility management. Another significant issue is the low adoption of improved crop and livestock technologies in the watershed. Other challenges include livestock feed shortages, lack of artificial insemination (AI) services, limited access to improved forage, and restricted access to cattle markets. Based on these findings, the following recommendations are made for further development in the Birbo watershed:

a) *Multi-disciplinary Interventions:* Interventions should involve various research disciplines to address the identified gaps and challenges effectively.
b) *Promotion of Improved Technologies:* Efforts should be made to popularize the adoption of improved crop varieties, livestock technologies, and best practices throughout the watershed.
c) *Soil Fertility and SWC Practices:* A range of soil fertility management practices and soil and water conservation (SWC) techniques should be implemented in the catchment area. Additionally, agroforestry practices should be introduced and promoted to enhance the sustainability of natural resource management in the Birbo watershed.

Abbreviations

EIAR	Ethiopian Institute of Agricultural Research
AI	Artificial insemination
SWC	Soil and Water Conservation
HH	Household
FGDs	Focus Group Discussions
SD	Standard Deviation
FYM	Farm Yard Manure
FTC	Farmers Training Center

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Conflicts of Interest

The authors declare no conflicts of interest.

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