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Analysis of Land Use Change from Forest to Agriculture and its Determinants: the Case of East Shewa, Oromia, Ethiopia

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ABSTRACT

The expansion of agricultural land through deforestation is becoming a serious problem in several regions of Ethiopia. The research was carried out in the Adami Tulu Jido Kombolcha district due to the observed expansion of agricultural land at the expense of forests. Therefore, this study aims to identify direct and indirect factors affecting land use and land cover change from forest to agriculture. Data was collected using household surveys, key informant interviews (KIIs), and focus group discussions (FGDs). Household surveys were conducted on 244 randomly selected households. Data were analyzed using descriptive statistics and the DPSIR framework to develop relationships between drivers, pressures, conditions, influences, and responses. The result shows that most farmers clear forests to expand their agricultural land. Further, the results showed that the proximate causes of the conversion of forest to agriculture were charcoal production, large-scale agriculture, and small-scale farming, as well as poverty, unemployment, and lack of enforcement of forestry laws, and weak forest policy were identified as the main indirect causes of agricultural land expansion at the expense of forests. In addition, the results indicate that the consequences of changing land use from forestry to agriculture are loss of biodiversity, increased soil erosion, floods and droughts, and shortages of wood, buildings, and fuel. The study results suggest that awareness-raising activities on the use of natural resources and the impacts of deforestation, as well as forest policies and strict enforcement of forestry laws, are important to establish and maintain appropriate use of land in that particular area.

INTRODUCTION

Land use change (LULCC) is driven by many factors that interact at global, regional, and local scales (Cheruto et al, 2016). In recent decades, Ethiopia has experienced significant changes in land use resulting from significant changes caused by human-environment interactions (Fasika et al., 2019; Grinblat et al, 2015). The dynamics of LULCC were not similar in all regions of the country due to different causal factors and became complex depending on the operational scale of cases and impacts (Berihun et al., 2019; Boor et al., 2014). Previous studies show that the main causes of LULCC observed in different regions were a combination of direct and hidden causes (Zaveri, 2020; Meshesha et al., 2016; Meyfroidt, 2015). Direct actions imposed by people at the local level are called proximate causes while underlying causes are defined as fundamental social processes practiced at the local level that indirectly influence and accelerate the effects of proximate causes (Zegeye et al., 2017; Geist et al., 2002). In Ethiopia, high demand for wood products and the shift to agriculture are putting pressure on forest resources.

For instance, in the northwest and northeast of the country, the cultivated areas have increased significantly in favor of forest cover (Sisay and Gitima, 2020; Tolessa et al., 2017) and in the east of

Ethiopia (Assen, 2011). A study by Abera et al. (2019) shows that the country's cultivated area increased by 6 million hectares in 8 years reaching 15.4 million in 2009. Many researchers such as (Aklilu et al. 2019; Hailemariam et al., 2016; Alemu and Abebe, 2011) further show that there is rapid forest and land degradation in Ethiopia due to a growing population, which in turn leads to massive deforestation for agricultural purposes, overgrazing, forest exploitation especially for firewood, feed and construction materials, and fires, create pastures and expand settlements. Reduction of natural vegetation cover for agricultural development is a critical challenge in the country (Duguma et al., 2019; Hassen and Assen, 2018; Gashaw et al., 2018; Gebrehiwot et al., 2014; Shiferaw, 2011). For example, in the middle highlands of Ethiopia, there is a massive extension of cultivated areas as well as urban and peri-urban areas over the end of most of the half-century in favor of forests (Belayneh et al., 2020; Minta et al., 2018).

Although subsistence agriculture is the country's main source of income, the expansion of agricultural land in favor of forests has had negative impacts on ecosystem service functions and biodiversity conservation activities (Danano et al., 2018; WoldeYohannes et al., 2018; Kindu et al., 2016a; Meshesha et al., 2015). Most previous studies have focused on quantifying the magnitude of changes in land use and land cover using remote sensing images. However, a thorough understanding of the drivers and consequences of LULCC, particularly the transition from forest to agriculture, is crucial to developing more effective environmental policies and appropriate land management strategies for the entire locality (Worku et al., 2018; Larigauderie and Mooney, 2010). An in-depth study of the factors affecting land use dynamics is crucial for policymakers in developing sustainable land use management plans (Burgi et al., 2017; Kamwi et al., 2015).

Thus, the main objective of this study is to examine and find explanations for local people's perceptions of the driving forces of LULC change and associated pressures, impacts, and responses in the study area. Therefore, this study aims to 1) assess the direct and indirect factors affecting land cover conversion from forest land to agriculture and 2) examine the farmers' perception regarding pressures, status, impacts, and responses of land use conversion from forest to agriculture. The results of this study will provide the basis for a clear picture of land use change that planners, conservationists, policymakers, and other stakeholders can use to formulate sound land use management and natural resource conservation and utilization strategies in Ethiopia.

MATERIALS AND METHODS

Study Area

The Central Rift Valley is located at 170 km in south of Addis Ababa, Ethiopia. Adami Tulu Jido Kombolcha District is located in the heart of the central Rift Valley, southwest of Lake Ziway, at latitude 70°50' North and longitude 380 42'East. The climate zone is semi-arid (Abera et al., 2016). Annual precipitation varies between 600 and 800 mm and is characterized by bimodal rainfall. In the months of April and May, rainfall falls very briefly and unreliably, while most rainfall falls within three months (June-August) and sometimes until September (Martha et al., 2020). The Adamitulu-Jido Kombolcha district was selected for our study due to its high deforestation rate due to agricultural expansion. According to the district agriculture office, a significant part of the population lives in mixed agriculture, which includes animal and crop production.

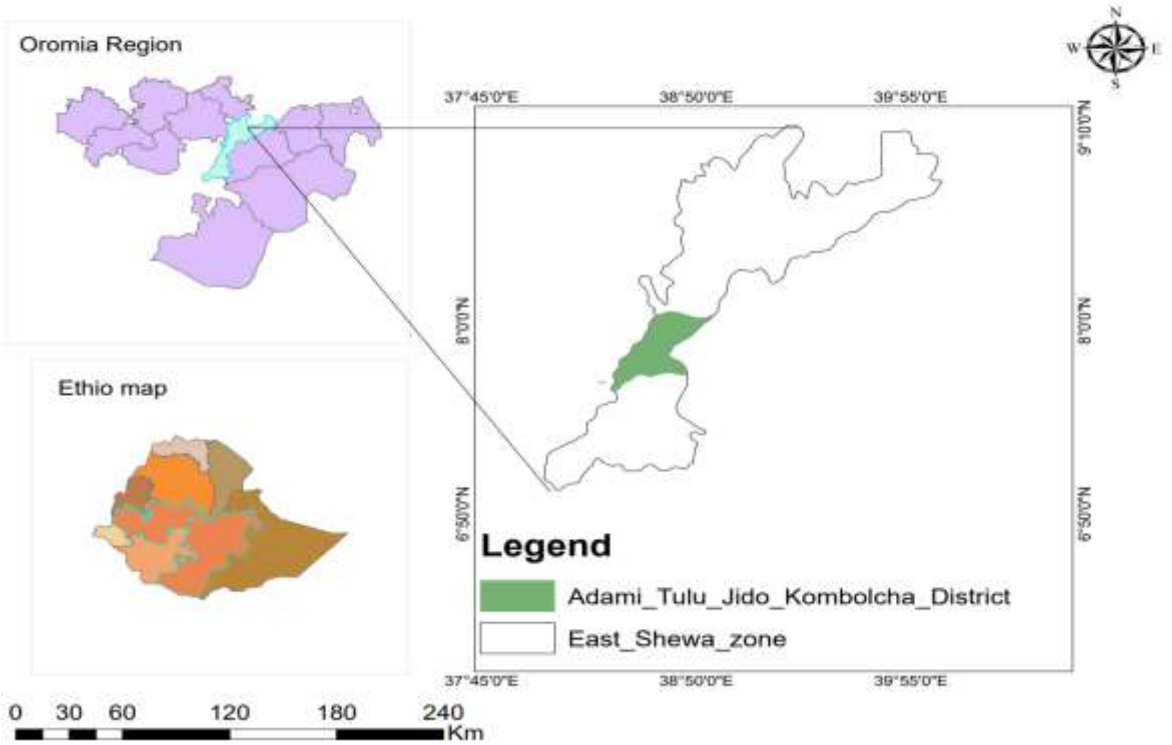

Figure 1. Study Area Map

Sampling Methods

A multistage sampling method was used. First, one potential district was selected, namely Adami Tulu Jido Kombolcha of East Shewa Zone in Oromia Regional State. The selection of the potential district was based on consultations with territorial, agricultural, and natural resources officials. Two potential kebeles (Andola Chabi and Woyiso Kenchera) from the selected district were then purposively selected, taking into account the extent of land use change from forestry to agriculture. A simple random sampling technique was then used to select respondents for the sample. Households from the selected districts were then randomly selected. A formula developed by Chohran (1977) was used to determine the sample size in the selected district.

$$n=\frac{N*Z^2p*q}{e^2\left(N-1\right)+Z^2*p*q} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$n=\frac{667*\left(1.96\right)^2 0.5*0.5}{0.05^2\left(666-1\right)+(1.96)^2*0.5*0.5}$$

n=244

Where: n = Sample size of household heads; P= 0.5, the maximum level of variability taken when previous population variability is unknown; q = 1-0.5 i.e., 0.5; e is the precision level and N=Total population size of the selected villages, obtained from the administrative office of the selected districts. The total household numbers in both selected districts are 667. Therefore, by using the above formula our sample size is 244 households.

Data Collection Methods

Structured and semi-structured questionnaires were used to collect information from the households interviewed in the study area. The survey targeted respondents who had lived in a particular area for at least 10 years and decision-makers in the family. The questionnaires contained questions to collect general information about the households, the farmers, and the history of use of the family plots. In addition, farmers were asked for their opinions on the drivers, pressures, status, impacts, and responses to land cover changes. The FGDs were also carried out, in which a questionnaire served as a guide for the discussion. Various groups from the administration, community, and women took part in the discussion. A total of 2 group discussions were conducted for each of the selected districts. Each group discussion consists of 10 people. The KIIs were conducted to gain an in-depth and detailed understanding of how local people perceived the land use changes that occurred in the study area and the associated causes that they believed contributed to these changes. The district administrator and officers responsible for agriculture and natural resources were included in the KII.

Data Analysis

Descriptive and ranking indexes were applied for the analysis of quantitative data. For interpretation, the questionnaire results were complemented with qualitative results gained in FGDs and KIIs. The socioeconomic data derived from the questionnaires were entered, processed, coded in SPSS, and analyzed using STATA version 17. Descriptive statistics analysis was used to describe the socioeconomic variables of the households and summarize their responses and ranking of drivers of land use change.

The DPSIR model was used to incorporate the household perception of the drivers of land use change. In addition, ranking the drivers of land use change perceived by the respondents was carried out according to the weighted average principle using the ranking index adopted by Musa et al. (2006) and Solomon et al. (2017).

$$\text{Index}=\frac{R_nC_1+R_{n-1}C_2 \ldots\ldots + R_1C_n}{\sum R_nC_1+R_{n-1}C_2 \ldots\ldots + R_1C_n} \quad \ldots\ldots(2)$$

Where R_n = value given for the least-ranked level (for example, if the least rank is the 10^{th}, then $R_n = 10$, $R_n - 1 = 9$, $R_1 = 1$; C_n = counts of the least ranked level (in the above example, the count of the 10^{th} rank = C_n, and the count of the 1^{st} rank = C_1).

RESULTS AND DISCUSSION

Socio-economic Characteristics of Households

The majority (90.57%) of respondents were married, 5.33% were separated and only 4.1% were single. The maximum age of the head of household was 70 years and the minimum age was 16 years. The average size of the respondents was 7.47 people, while the maximum and minimum household sizes were 20 and 2 people, respectively. The average number of years a household lived in the study area was 35.9 years. The respondents own land with a maximum area of 12 hectares. The average tropical livestock unit was 4.31. In terms of education level, the majority (58.20%) of the surveyed households completed primary school, followed by 21.31% of households that have a secondary school education. Specifically, 0.82%, 2.46%, and 0.41% of them have a diploma, degree, and higher respectively. However, 16.80% of the respondents were illiterate. The main activity of the respondents was managing a farm in their own lands, which was confirmed by 95.5% of the respondents. 4.5% of households' main occupations also include regular wage, irregular wage, self-employment, and unpaid family work.

Table 1. Socioeconomic Characteristics of Respondents

Number of observations (N=244)						
Variables		Mean	Std. Deviation	Minimum	Maximum	(%)
Age		38.47	12.83	16	70	
Family size		7.47	2.79	2	20	
Sex (1= male)		.57	.49	0	1	
Years lived in the study area		35.91	14.4	3	70	
Livestock holding (TLU)		4.31	4.32	0	27.3	
Total land holding size		2.08	1.60	0	12	
Educational status	Illiterate					16.80
	Elementary					58.20
	High school					21.31
	Certificate					0.82
	Diploma					2.46
	Degree and above					0.41

Marital status	Unmarried	4.10
	Married	90.57
	Separated	5.33
Main occupation	Work on own farm	95.5
	Others	4.5

Households in the research site allocated the maximum amount of land for agriculture with an average of 1.3682 depending on the land area on their property. Crop cultivation is the key income source in most regions of the country and more and more land is being allocated to agriculture (Ariti et al., 2015), while a small area of land is being allocated to forest plots. In the research site, the majority of households are Muslim, allowing double marriage. Therefore, because they have large families, more agricultural production is necessary to meet their food needs. This result is also in line with the results of Mola, 2014; Kindu et al., 2013 point out that farmers are expanding their farmland to meet the agricultural needs of families as population growth increases.

Table 2. Land Allocation for Different Land Use Types

Land allocation (ha)	Mean	Std. Dev.	Min	Max
Homestead	0.5847746	.8144955	0	4.25
Farmland	1.368272	1.814016	0	11
Woodlot	0.1066598	.6018654	0	7.5
Other land use	0.0069057	.0963872	0	1.5

Farmers in the research area have different income sources. Their major income source was livestock farming, from which farmers could earn an average of 122,366.3 birr per year. The second key income source in the research area is agricultural production, which averages Birr 47,593.35 per household per year.

Table 3. Sources of Income in the Study Area

Income sources	Mean (ETB)	Std. Dev.	Min	Max
Pretty trade	665.1639	6830.136	0	100000
Daily labourer	865.1639	4950.028	0	50000
Selling of forest products	54.91803	474.988	0	5200
Remittance	9.836066	153.6443	0	2400
Guard	383.7869	2604.219	0	24000
Full-time government employment	698.0164	5983.511	0	74316
Crop production	47593.35	48542.86	0	304000
Livestock production	122366.3	253197.2	0	2417400

Farmers' Perception Regarding the Change in Crop Production and Forest Cover in the Last 10 Years in the Study Area

The majority (77%) of respondents reported a decline in crop productivity. On the contrary (75.3%) of those surveyed stated that the forest area had declined in the last 10 years, at most to the extent that it was converted into arable land (Fig. 2). The likely reason for this is that farmers have expanded their agricultural areas to compensate for declining land productivity and to pass on donations from family members to the new family (Kindu et al., 2013; Meshesha et al., 2012a). A small number (19.8%) of respondents in the study area also reported that an invisible change in forest cover had occurred. 19.2% also believe that there has been no change in crop productivity in the last 10 years.

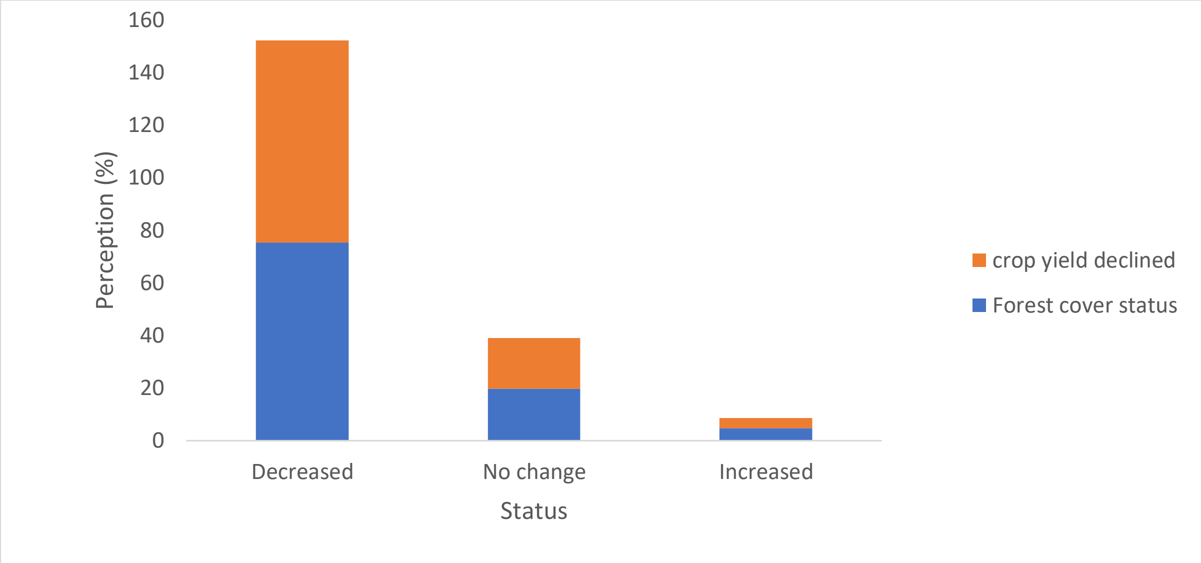

Figure 2. Status of Forest Cover Change and Land Allocation for the Last 10 Years

The farmers in the research area have large families, most have had double marriages and need more agricultural land to support themselves. The majority (69.1%) of respondents confirmed that they had expanded their agricultural areas by clearing forest areas, followed by pasture areas (13.3%) and woodland (8.2%) (Figure 3). A similar study by (Babiso et al., 2020) found that the forest cover decline is mainly due to the expansion of agriculture.

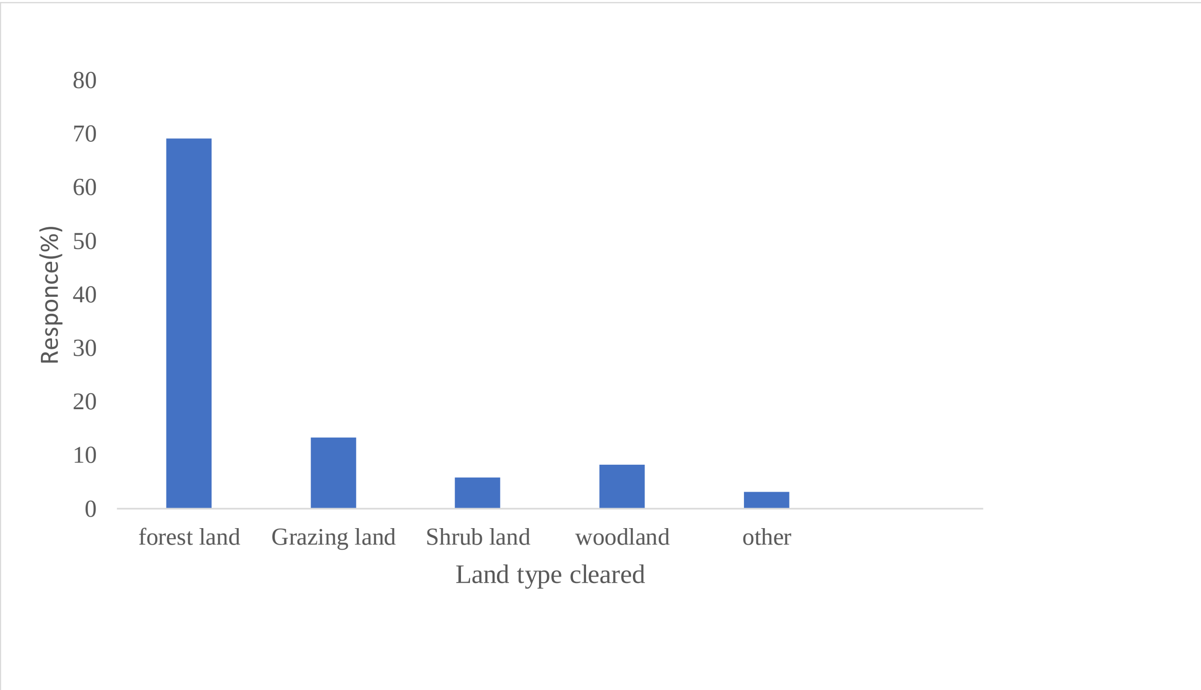

Figure 3. Land Type Cleared by Households for Cropland

According to the respondents, the decline in yield is explained by repeated cultivation due to limited area, followed by unstable rainfall, high incidence of pests and diseases, soil infertility lack of improvement of seeds and their quality, and inadequate workforce. were the most common cause of lower returns (Table 4). A previous study by (Ariti et al., 2015) found that land scarcity and soil infertility were the main causes of declining agricultural yields.

Table 4. Cases for the Declining Crop Reduction

Cause	Weighted frequency												index	Rank
	1	2	3	4	5	6	7	8	9	10	11	12		
Repeated farming due to limited land	35	222	30	39	9	12	17	4	3	15	12	32	0.277	1
Unreliable rain falls	12	7	16	54	35	68	22	13	10	11	12	44	0.139	2
Frequent pests and diseases	11	2	5	13	27	47	37	21	30	21	14	27	0.102	3
Soil infertility	13	11	8	21	21	41	24	9	9	14	5	20	0.092	4
Lack of improved seed and seed quality	15	3	9	8	38	23	22	5	9	10	5	20	0.078	5
Inadequate labor	23	15	11	7	11	3	14	7	13	13	10	6	0.068	6
Lack of agricultural input and Price fluctuating of crop products	15	8	13	4	11	10	8	31	19	19	5	1	0.067	7
Lack of knowledge	16	3	26	9	14	4	11	15	7	9	4	11	0.065	8
Lack of money for input	10	13	14	3	4	10	4	17	14	28	14	6	0.058	9
Low market price	11	5	8	2	6	15	6	20	26	14	19	5	0.054	10

As noted by key informants, stakeholders, and households interviewed in the study area, agricultural land was unsuitable for agricultural production. To solve this problem, farmers have used various techniques. The majority (69%) of respondents said they want to improve soil fertility to maximize yields and then look for additional land, fallow land, and other methods such as shifting cultivation (12.9%, 11.3%, and 6) .8% (Figure 4). A similar study by (Ariti et al., 2015) shows that crop rotation and the use of fertilizers and pesticides were common methods used by farmers to improve agricultural production and feed family members.

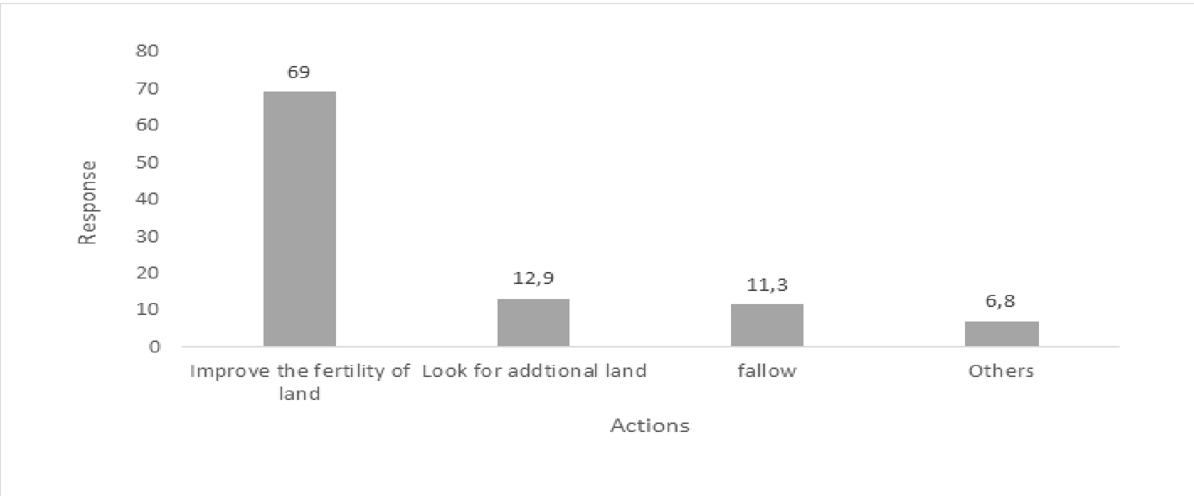

Figure 4. Farmers' Responses to Wards Crop Yield Reduction

The direct factors affecting land use and land cover change from forest to agriculture were ranked and presented in Table 5. According to respondents' responses, the immediate drivers of deforestation included charcoal production, large-scale agriculture, small-scale agriculture, and firewood collection. This was considered the most common reason for the conversion of forest areas into agricultural land. The result is consistent with the findings of (Belay, 2018; Degife et al.,2018;

Enbakom et al., 2017; Ariti et al., 2015; Tariq and Aziz, 2015). found that the main factors driving farmers to convert forest land to cropland are charcoal production, firewood collection, and investment, with the main factors identified in large-scale agriculture. There is a shortage of agricultural land in the study area, which was confirmed by farmers. As a result, attempts were made to find another alternative to expand agricultural land. A similar study found that declining soil fertility forces farmers to expand their farmland to compensate for low yields on existing farmland and to meet family needs (Meshesha et al., 2012a). In the study area, large-scale agriculture was carried out by investors who converted forest areas into agricultural land for growing maize and other crops for various purposes. Key informants and panelists also noted that farmers tend to convert their forests into agricultural land due to the growing demand for agricultural products and the resulting increase in family size (Maja and Ayano, 2021; Ariti et al., 2015). The result is also similar to (Madalcho et al., 2020; Yohannes et al., 2017). findings, which stated that farmland expansion, firewood collection, charcoal production, and forest fire were identified as direct causes of deforestation.

Table 5. Direct Drivers of Conversion from Forest to Agriculture

Direct drivers	Weighted frequency					index	Rank
	1	2	3	4	5		
Charcoal production	112	65	41	4	7	0.171	1
Largescale agriculture	134	25	19	5	11	0.151	2
Small scale agriculture	92	49	19	12	10	0.133	3
Firewood collection	65	45	35	13	10	0.115	4
Less availability of cropland	14	16	19	19	29	0.046	5
Forest fire	22	7	10	12	29	0.039	6
Timber harvesting	1	5	5	9	37	0.017	7

In addition, poverty, unemployment, non-enforcement of forest laws, weak government forest policy, and land insecurity are the main indirect causes of the transition from forestry to agriculture (Table 6). The reason for this could be the increase in family size, which leads to an increase in consumption of plant-based products, which leads to poverty. Therefore, they need to actively engage in agricultural practices to address food shortages in their livelihoods. Forestry legislation plays a key role in protecting forests from deforestation. Otherwise, non-enforcement leads to intensive and indiscriminate deforestation of trees for various purposes (Teweldebirhan et al., 2023). This result is also related to the study by Madalcho et al. (2020), who found a lack of awareness about forest management due to the government's weak forest policy was a cause of deforestation.

Table 6. Indirect Drivers of Land Use Land Cover Change from Forest to Agriculture

Indirect driver	Weighted frequency					index	Rank
	1	2	3	4	5		
Poverty	197	30	4	1	2	0.140	1
Unemployment	79	72	27	14	22	0.102	2
Lack of forest law enforcement	60	37	20	24	12	0.071	3
Weak forest policy from the government	57	26	29	24	9	0.067	4
Land tenure uncertainties	56	32	27	13	16	0.066	5
Poor environmental impact assessment	54	26	14	10	27	0.058	6
Weak leadership from the local government	35	29	31	26	18	0.057	7
Settlement	38	24	27	14	26	0.053	8
Increased agricultural output price	39	21	24	17	28	0.052	9
Low education on the role of forest	36	20	20	13	44	0.049	10
Less land quality	32	16	32	18	32	0.048	11
Political interference	50	12	8	12	32	0.047	12

Pressures Exerted, States, Impacts, and Response Due to Land Cover Change from Agriculture to the Forest in the Study Area

Pressures associated with land cover change from forest to agriculture were believed to include high demand for forest land (83.1%), changes in soil moisture (78.5%), increased demand for forest products (75.5%), and livestock pressure (68.8%). This finding is consistent with those of Teweldebirhan (2023), who cited increased demand for forest products, changes in soil moisture, livestock pressure, and intensive farming as stress associated with the expansion of agricultural land at the expense of forest land. A previous study by Gedefaw et al. (2020) also shows that stress from competition on communal land, overgrazing of land, demand for agricultural land, increased demand for forest products, selective cutting of trees, and changes in soil moisture led to deforestation.

Table 7. Pressure Exerted Due to Forest Land Conversion to Agriculture

Pressure	Frequency	Proportion (%)
High demand for forest land	197	83.1
Soil moisture change	186	78.5
Increased demand for forest products	179	75.5
Overgrazing of land	163	68.8
Overuse of natural resource	160	67.5
Competition on communal land	148	62.4
Intensive cultivation	117	49.4
Selective cutting of trees	106	44.7

In the study area, the current conditions observed due to land use/cover change from forest to agriculture as confirmed by households are rainfall variation (98.3%), wildlife disturbance (95.4%), soil erosion (92.1%), and forest Coverage change (90.4%). Causes to switch from livestock farming to agriculture due to the lack of grass as a result of deforestation. Most of these states were also reported by Gedefaw et al., (2020).

Table 8. State Observed Due to Agricultural Expansion in the Expense of Forest

State	Frequency	Proportion (%)
Rainfall variability	236	98.3
Wildlife disturbance	229	95.4
Soil erosion	221	92.1
Forest cover change	217	90.4
Change from animal husbandry to crops	198	82.5
pest and disease occurrence	141	58.8
Poor water quality	134	55.8

The main impacts reported by farmers were loss of biodiversity (90.7%), increased soil erosion, floods and droughts (82.7%), lack of timber construction and fuel (72.2%), and reduction in livestock production (70.9%) (Table 9). This is due to the lack of grass for livestock that was previously available in the forest. Similar results were also found in the study by Gedefaw et al. (2020) conducted in Gozamin district. Furthermore, many studies indicated that land use land cover change leads to a loss of biodiversity and decreasing availability of products and services for humans (Muke, 2019; Milkias and Toru, 2018; Wubie et al., 2016; Teshome, 2014).

Table 9. Impacts of Land Use Land Cover Change from Forest to Agriculture

Impact	Frequency	Proportion (%)
Loss of biodiversity	215	90.7
Increased soil erosion, flood, and drought	196	82.7
Lack of wood for construction and fuel	171	72.2
Livestock production reduced	168	70.9
Decrease in water resource	165	69.6
Disease	134	56.5

The majority (89.2%) of households believe that farmers and stakeholders should adopt conservation and restoration measures to minimize the impact of land use change dynamics (Table 10). In addition, the household identifies solutions to address these challenges: agricultural intensification, family planning, training farmers on the role and management of forests, diversifying income-generating activities, employment opportunities, using renewable energy, and consideration of land use policy.

Table 10. Response Would Apply to Minimize the Impacts of Land Use Land Cover Change

The response should be taken	Frequency	Proportion (%)
Conservation and rehabilitation of resource	207	89.2
Agricultural intensification	158	68.1
Family planning	130	56.0
Training of farmers on forest role and management	115	49.6
Diversification of livelihood income	113	48.7
Use of renewable energy	108	46.6
Consideration of land use policy	95	40.9
Improving the education level of the community	92	39.7
Enforcement of laws and regulations	79	34.1

CONCLUSION

Adami Tulu Jido Kombolcha district in East Shewa is experiencing heavy deforestation for agricultural production. The result shows that farmers in the study area devote more land to agricultural production. Most respondents confirmed that they expand their agricultural land by clearing forest areas because they have large families and need more agricultural land for their livelihood. Although agriculture was the main source of income, arable land became unsuitable for agricultural production and difficult to manage without fertilizers. According to households in the study area, the main reasons for yield decline were repeated cultivation due to limited area, unstable rainfall, high incidence of pests and diseases, infertile soils, and lack of improvement of seeds and their quality. To solve this problem, farmers have used various techniques to boost soil fertility and maximize yields, such as B. searching for additional land, leaving the land fallow, and using other methods such as shifting crops. This study revealed that charcoal production, large-scale agriculture, small-scale agriculture, and firewood collection were the main direct causes of the conversion of forest land to agricultural land.

While; Poverty, unemployment, non-enforcement of forestry laws, weak state forestry policies, and insecurity over land ownership were the main indirect causes of the transition. Pressures resulting from land cover change from forest to agriculture were frequently cited as high demand for forest land, changes in soil moisture, and increased demand for forest products. Consequences include loss of biodiversity, increased soil erosion, floods and droughts, and increased migration from rural to urban areas as reported by agricultural households in the study area. Based on the results of this study, strict forest policy and enforcement of forestry laws are recommended to address the increasing conversion of forest land to agricultural land in the study area.

The results also suggest that it is important to pay attention to agricultural intensification, family planning, training, and creation of employment opportunities to minimize forest destruction for agricultural expansion.

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