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# Land use land cover change and expansion of Eucalyptus plantations in Senan District, northwest Ethiopia: analysis of potential factors

**Fasika Belay** [1*], **Messay Mulugeta** [2], **and Teferee Makonnen** [1]

[1]*Department of Geography and Environmental Studies, College of social sciences, Addis Ababa University*
[2]*Center for food security, College of Development Studies, Addis Ababa University, P.O.Box 1176, Addis Ababa, Ethiopia*
*Corresponding author; Email: fasika.belay@aau.edu.et*

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**Abstract**
*In Ethiopia's highlands, farmers are quickly turning their farmland into eucalyptus plantations, which could have an impact on the local economy and environment. In Northwest Ethiopia, more especially in the Senan district, the growth of eucalyptus tree plantations at the expense of other land use practices is being evaluated, along with the reasons that contribute to this phenomenon. 166 houses that planted eucalyptus and 166 households that did not were the subjects of the data collection, which was then subjected to binary logit analysis. Utilizing Landsat satellite imagery from four different time periods (1990, 2000, 2010, and 2021), the research area's land use and land cover changes were examined. Using a supervised classification approach, the land use and land cover classes were split out. The results showed that agriculture decreased from 58.4% in 2010 to 38.1% in 2021, while vegetation cover—which is primarily composed of eucalyptus—increased from 16.8% to 26.5% in the same time frame. The binary logit analysis's findings show that while family size, educational attainment, livestock ownership, and the fertility of farmers' land had a significant negative impact on eucalyptus plantation, the age of the household head, the size of the farmers' land, and savings had a positive and significant impact on the adoption of eucalyptus plantation. In order to evaluate how eucalyptus plantations affect farmers' livelihoods and guarantee that their well-being is enhanced as a result, comparative research is advised.*

**Keywords/Phrases**: Driving factors, Ethiopia, Eucalyptus, GIS, Land-use change

## 1 Introduction

The most common tree species planted worldwide is eucalyptus (Abebe *et al*., 2019). It has rapidly spread over the world within the past century. It was brought to Africa, more especially Ethiopia, in the 1890s (Jaleta *et al*., 2016).

Zenebe (2016) noted that in terms of livelihoods, eucalyptus plays an important role in addressing food security. Besides, according to Elli *et al*. (2019), the availability of fuelwood is one of the most important contributions of eucalyptus to food security. Cooking, for example, is the most common method of ensuring food utilization through high nutritional absorption from food, and 2.4 billion people use fuelwood to cook.

There is still some criticism of eucalypt plantations despite their many advantages, especially in East Africa where the majority of people rely on wood for fuel and construction. Divergent opinions exist on the economic, social, and environmental sustainability of eucalyptus trees among their users, growers, environmentalists, researchers, and legislators.

The majority of concerns raised are related to the environmental impact, particularly concerning soils, water, and biodiversity (FAO, 2011). On the contrary, according to Sembiring, *et al* (2020) and Silenat and Fikadu (2018), Eucalyptus is a plant that has many positive effects on the environment, such as lowering the risk of forest fires, floods, and erosion; improving water efficiency; restoring degraded or unproductive land; and increasing biodiversity over time. On the other hand, Zenebe (2006) stated that Eucalyptus hurts yield and inhibits undergrowth. However, almost all the firewood, building materials for houses, farm implements, and other materials in the village are made from Eucalyptus. As a result, the benefits outweigh the negative impacts, which can be mitigated by planting Eucalyptus in areas that are unsuitable for agriculture and spacing them widely apart, even in farmlands and borders.

Even though eucalyptus plantations are generally criticized, farmers in Ethiopia, particularly in the northwest highlands, including the Senan district have converted their cropland into eucalyptus plantations (Amare *et al*, 2021). Previous studies have identified various factors associated with the expansion of eucalyptus plantations in Ethiopia. For instance, the age of the household head (Gebreegziabher *et al*., 2010; Tegegne *et al*., 2018), the education level (Kebede, 2017; Asabeneh & Yoseph, 2022), sex of the household head (Zenebe *et al*., 2020), family size (Setiye & Mulatu, 2016), wood demand (Tola, 2010), land degradation (Berihun & Habtemariam, 2017), the need for immediate cash (Tola, 2010), adaptability to wider agro-ecological zones, affordable cost of production ( Gashaw *et al*, 2023). and low labor requirements for management (Berihun & Habtemariam, 2017) have all been identified as significant factors influencing land use patterns and the expansion of eucalyptus plantations in Ethiopia. These factors play a significant role in shaping land use patterns and the expansion of eucalyptus plantations in Ethiopia. However, it is important to acknowledge that these factors may vary in different contexts.

While previous studies have provided some insights into the conversion of croplands to eucalyptus plantations in Ethiopia, including the Senan district, there is a lack of adequate research, specifically focusing on the land use and land cover change in this district and the reasons behind the conversion. Amare *et al*. (2022) highlighted that smallholder farmers in the northwestern highlands, including the Senan district, have recently started converting their croplands to eucalyptus plantations. However, their study was conducted across three districts and did not separately analyze the driving factors specific to the Senan district. Therefore, this study assesses the land use land cover change and the factors that motivate farmers to convert their croplands into Eucalyptus plantations in the Senan district.

## 2 Materials and Methods

### 2.1 Description of the Study Area

Senan is situated in Ethiopia's East Gojjam Zone, which is between latitudes 10° 25' 13" N and 10° 40' 30" N and longitudes 37° 40' E and 37° 50' 20" E (Lakachew, 2022). There are two urban and seventeen rural kebeles in the district. The district sits between 2300 and 4154 meters above sea level. Notably, this district is home to Mount Choqe, also referred to as the "water tower of Ethiopia." At 4154 meters above sea level, it is the highest point in both the district and the East Gojjam Zone (Senan District Communication Affairs Office, 2021).

Approximately 25% of the land in the district consists of plateau and plain surfaces, while mountains and hills make up around 60%, and valleys account for approximately 15% of the landform. Eucalyptus globules are the dominant vegetation in the study area (Senan District Communication Affairs Office, 2021).

As per 2007 national census, this district is home to 98,939 people overall (CSA, 2007).

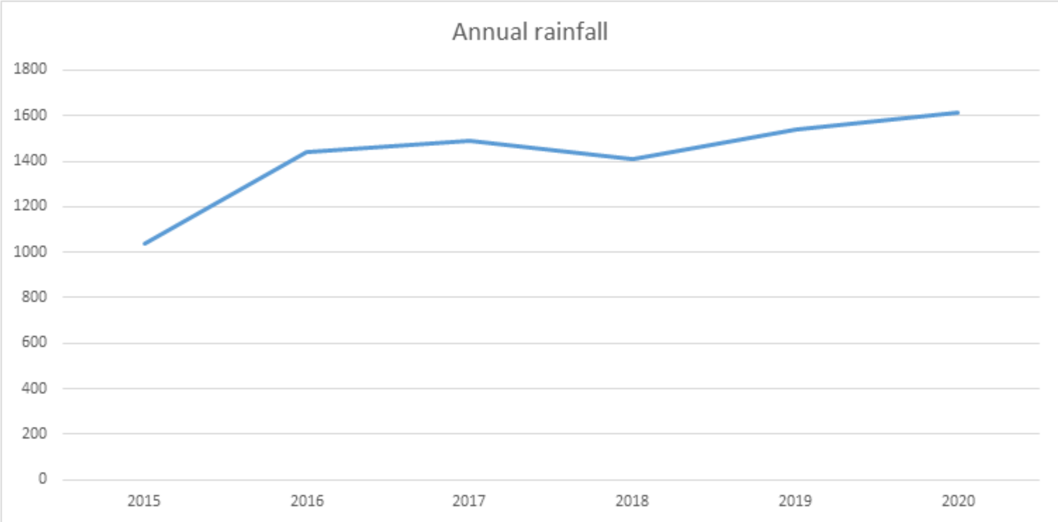



**Figure 1.** Annual Rainfall of Senan District (2015-2020)(CSA, 2022)

The daily average temperature is 15 degrees Celsius and the annual rainfall in the district is between 900-1500 mm (Central Statistics Agency, 2022).

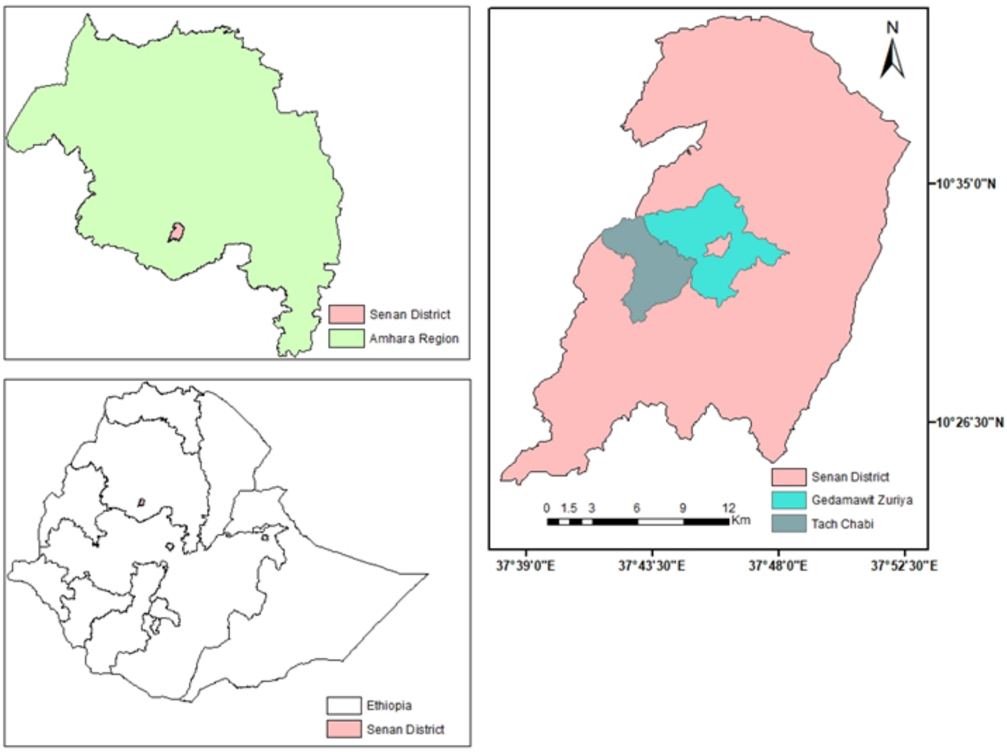



**Figure 2.** The location map of the study area

## 2.2 Data Sources and Processes

Both primary and secondary data sources were employed in this investigation. Questionnaires, in-person observations, key informant interviews, focused group discussions, and GPS instrument surveys were used to gather the primary data, while satellite photos and documents and reports from different organizations were utilized to gather the secondary data.

**Questionnaire**

The researchers collected quantitative data using a questionnaire from 166 households that had planted eucalyptus and 166 households that had not planted eucalyptus. Before undergoing a pilot test, the questionnaire was translated into Amharic, the local language.

**Personal Observations**

We conducted field observations by walking through the district with agricultural office experts in the area. This method assisted us in comprehending the expansion of eucalyptus plantations. The observation was also carried out at the district's local marketplace, where we asked questions and took notes on what we had seen, further enhancing our understanding of the situation.

**Key Informant interviews and focus group discussions**

In order to gain insight into the factors influencing eucalyptus plantations based on their perspectives and experiences, four focus groups and thirteen interviews with carefully chosen senior farmers and agricultural bureau officers were conducted. One criterion for determining when to cease gathering qualitative data was saturation.

**Satellite Image**

The United States Geological Survey (USGS: https://earthexplorer.usgs.gov) provided the study area's Landsat satellite imagery for four different time periods (1990, 2000, 2010, and 2021). The 2021 image was a Landsat 8 Operational Land Image and Thermal Infrared Sensor (OLI/TIRS), while the 1990, 2000, and 2010 images were Landsat 4-5 Thematic Mapper. The images were extracted in Tiff data format during January. This is the time when there is clear sky season in the study area, and important to detect vegetation. Moreover, this time is important to reduce atmospheric and radiometric problems. The detailed feature of the three Landsat satellite images is indicated in table 1.

**Ground Control Points**

Data collected by satellite sensors should be validated and compared to reality using reliable ground truth data. Therefore, real-world data were gathered using a hand-held GPS instrument for model validation and accuracy evaluation. To generate a land-use land-cover map, training data was collected from the field in order to have the appropriate spectral value for each class. The land use/land cover result was also verified using a Google Earth Pro image.

**Table 1.** Sources of secondary data

| No. | Data Type | Sensor | Date of acquisition | Path/Row | Resolution | Source |
|---|---|---|---|---|---|---|
| 1 | Landsat image | TM | 07/01/1990 | 169/053 | 30m by 30m | USGS |
| 2 | Landsat image | TM | 19/01/2000 | 169/053 | 30m by 30m | USGS |
| 3 | Landsat image | TM | 14/01/2010 | 169/053 | 30m by 30m | USGS |
| 4 | Landsat image | ETM+ | 28/01/2021 | 169/053 | 30m by 30m | USGS |

## 2.3 Sample Size Determination and Sampling Technique

The choice of the Senan district as the study area was driven by the presence of extensive eucalyptus plantations within the region. Because the research area's population is small, the Cochran modified formula—which is intended for a small population—was applied.

$$n = \frac{n_0}{1+(n_0-1)/N}$$

Here, $n_0$ is Cochran's sample size recommendation, $N$ is the population size, and $n$ is the new, adjusted sample size. Hence, the sample size will be:

$$n = \frac{385}{1+(385-1)/2392} = 331.89 = 332$$

To ensure representative coverage, a multistage sampling technique was employed. First, the seventeen rural kebeles of the district were categorized into two distinct agro-climatic groups: nine woina dega (subtropical) and eight dega (temperate) dominated kebeles. Then, the kebeles of Gedamawit and Tach Chabi were selected from each group. Households within the selected kebeles were stratified based on ownership of eucalyptus plantations. A proportionate stratified sampling strategy was used to choose 166 planters and 166 non-planters proportionately from each kebele's planters and non-planters. We were able to gather information from homes that plant and do not plant eucalyptus trees with the help of agricultural specialists from the two kebeles.

### 2.4 Data Analysis

Preparing digital images for human interpretation is known as digital image processing (Bakker *et al*., 2001). Pre-processing procedures have been carried out after downloading and extracting the satellite image. These include atmospheric rectification, layer stacking/merging, gap-filling, image mosaicking, clipping, and other image enhancement pre-processing procedures that were used to enhance the quality and interpretability of the image so that the images are appropriate and prepared for further analysis.

The development of thematic maps involves classifying the satellite image. The subjects could range from general categories to in-depth analyses of specific groups (Schowengerdt, 2007).

The study area's surface features were identified by composing images in various ways. For Landsat 4-5 TM, the classification was done using a true color composite known as RGB 321 (where band 3 reflects red, band 2 reflects green, and band 1 reflects blue), and RGB 432 (for Landsat 8 ETM+).

The land use classifications were conducted by using the maximum likelihood supervised classification. For all spectral classes, 155 training regions were created, making up each information class that the classifier would need to recognize. Based on the researcher's observations (ground truthing) and previous studies conducted in the field (Agenagnew *et al*., 2019; Aramde *et al*., 2014), the following classification schemes were created.

**Table 2.** LULC classes used for classification

| No. | Classes | Description |
|---|---|---|
| 1 | Settlement | Scattered settlements with houses separated from one another. |
| 2 | Cropland | This category includes area allotted for annual rain-fed and irrigated cultivation. Lands mostly used for cereal production in subsistence farming. Potato, barley, and beans are the main crops produced in the district. They farm using oxen and horse ploughs in the most traditional way. |
| 3 | Grassland | Area predominantly covered by small grasses with a small proportion of shrub and trees. |
| 4 | Vegetation | This unit includes a collection of plant species. Eucalyptus is the prominent species in the area. |
| 5 | Shrub land | Dominated land with isolated small trees always with a lower range of grass. |

One of the main data analysis techniques to determine the shift from farmland to vegetation was to calculate the area in hectares and the percentage of the resulting LULC categories for each research year, then compare the results. ERDAS IMAGIN and ArcGIS 10.8 software were used to make this analysis. The following diagram shows the overall workflow of the land use land cover change.

### 2.5 The Binary Logit Model

To assess the drivers of eucalyptus plantations in the study area, the dependent variable was categorized into two qualitative parts: whether or not to have eucalyptus plantations. Therefore, a binary logit econometrics model was employed to examine the factors that influence farmers' decisions to plant eucalyptus trees. In binary logistic regression analysis, the dependent variable must be categorical (it can be coded as 0 and 1) (Cokluk, 2010).

The functional form of logit model is specified as follows, according to Gujarati (2003);

$$P_i = E\left(Y = \frac{1}{X_i}\right) = \frac{1}{1+e^{-(\beta_1+\beta_2 X_i)}} \tag{1}$$

For ease of exposition, we write as

$$P_i = \frac{1}{1+e^{-z_i}} = \frac{e^z}{1+e^z} \tag{2}$$

Where, $Z_i = \beta_1 + \beta_2 X_i$.

If $P_i$, the probability of owning Eucalyptus plantation, is given by (2), then (1 - $P_i$), the probability of not owning Eucalyptus plantation, is

$$1 - P_i = \frac{1}{1+e^{z_i}} \tag{3}$$

Therefore, we can write

$$\frac{P_i}{1-P_i} = \frac{1+e^{z_i}}{1+e^{z_i}} \tag{4}$$

Now, $\frac{P_i}{1-P_i}$ is simply the odds ratio in favor of owning eucalyptus plantation—the ratio of the probability that a household will own the plantation to the probability that it will not own it. Finally, taking the natural log of equation we obtain:

$$L_i = ln\left(\frac{P_i}{1-P_i}\right) = Z_i = \beta_0 + \beta_1 X_i + \beta_2 X_2 + \ldots + \beta_n X_n \tag{5}$$

$$Z_i = \beta_0 + \beta_1 X_i + \beta_2 X_2 + \ldots + \beta_n X_n \tag{6}$$

$\beta_0$ is an intercept; $\beta_1$, $\beta_2$ ... $\beta_n$ are slopes of the equation in the model; $L_i$ = is log of the odds ratio, which is not only linear in $X_i$ but also linear in the parameters; $X_i$ = is vector of relevant household characteristics

If the disturbance term ($U_i$) is introduced, the logit model that has been used to analyze drivers of eucalyptus plantation in this study becomes;

$$Z_i = \beta_0 + \beta_1 X_i + \beta_2 X_2 + \ldots + \beta_n X_n + U_i \tag{7}$$

**Table 3.** List of independent variables in drivers of Eucalyptus plantations

| Independent variables | Description | Expected Effect |
|---|---|---|
| Age of household head (years) | Continuous | + |
| Sex of Household head | Female = 0, Male = 1 | - |
| Marital status of household head | Married= 1, Otherwise = 0 | + |
| Education level of household head (years) | Continuous | + |
| Family size (number) | Continuous | - |
| Farm size (Ha) | Continuous | + |
| Farm fertility (%) | Continuous | - |
| Livestock ownership (TLU) | Continuous | - |
| Membership of cooperatives | Not a member = 0, Member = 1 | + |
| Savings | No savings = 0, Have savings= 1 | + |
| Access to savings and credit service | No access = 0, Have access = 1 | + |

## 3 Results and Discussions

### 3.1 Land Use and Land Cover Analysis

The analysis comprises the land use land cover analysis and the factors behind the expansion of eucalyptus plantations. As the classification scheme indicated, cropland, grassland, vegetation settlement, and shrub land area are the major LULC classes of the study periods. The classified images were acquired when crop harvesting had already been completed, farmlands appeared bare, and grasslands looked relatively bright in color.

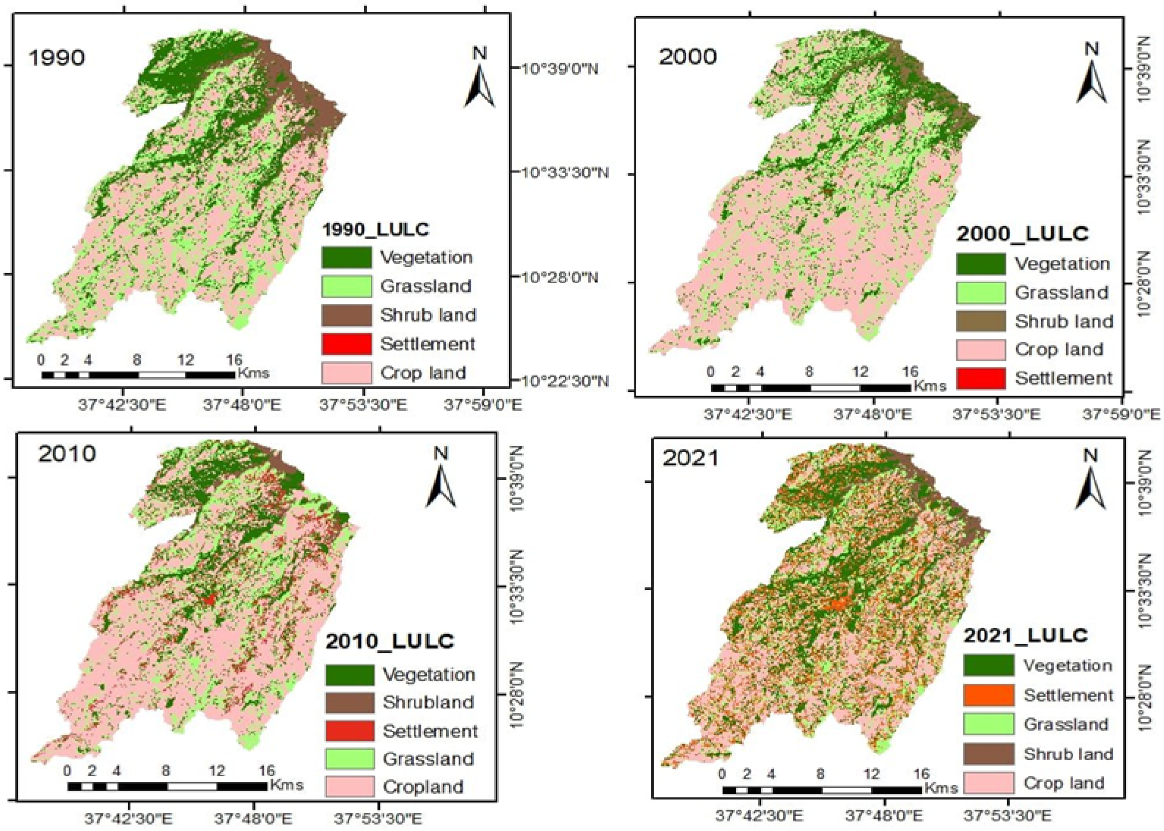



**Figure 3.** Land use land cover map of Senan district (1990, 2000, 2010, and 2021)

Figure 3 shows the land use land cover classes of the study area in 1990, 2000, 2010, and 2021.

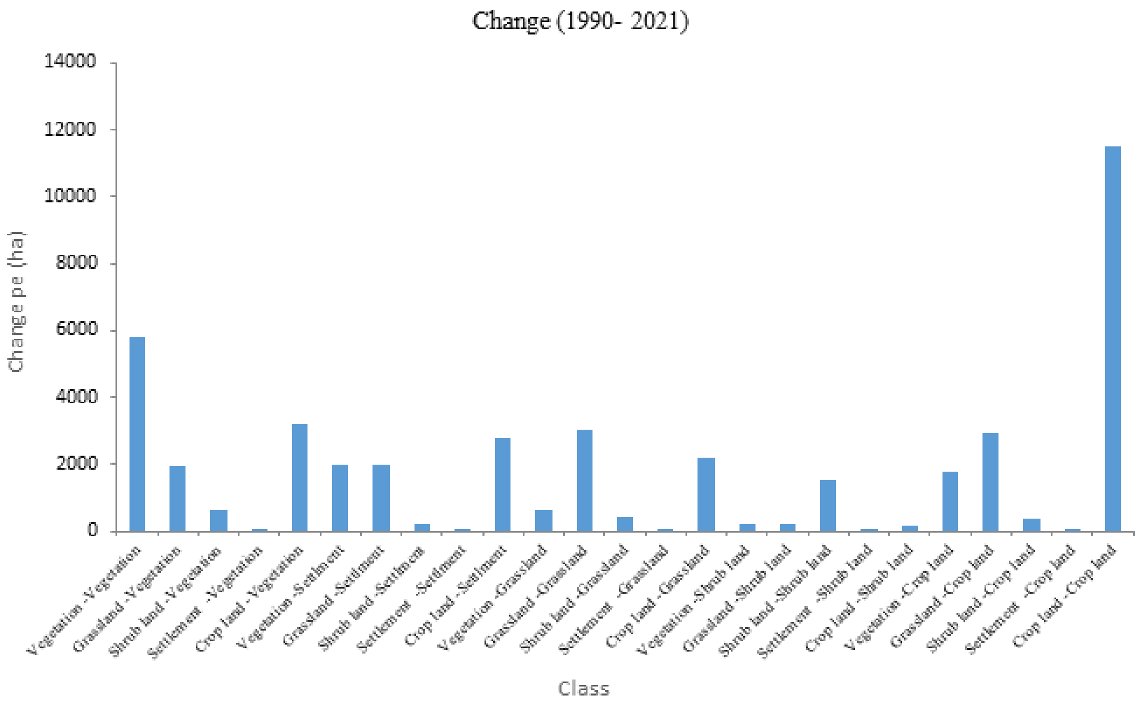
**Table 4.** LULC classes and their spatial extent with the observed changes over time

| LULC classes | 1990 | | 2000 | | 2010 | | 2021 | |
|---|---|---|---|---|---|---|---|---|
| | Area (ha) | Percent | Area (ha) | Percent | Area (ha) | Percent | Area (ha) | Percent |
| Crop land | 19750 | 45.2 | 25049 | 57.4 | 25500 | 58.4 | 16647 | 38.1 |
| Vegetation | 10408.5 | 23.8 | 7456 | 17.1 | 7294 | 16.8 | 11558 | 26.5 |
| Grassland | 10151.6 | 23.3 | 9406 | 21.6 | 6911 | 15.8 | 6297 | 14.4 |
| Settlement | 110.9 | 0.3 | 128 | 0.3 | 2334 | 5.4 | 6996 | 16.1 |
| Shrub land | 3215 | 7.4 | 1597 | 3.6 | 1597 | 3.6 | 2138 | 4.9 |
| Total | 43636 | 100.0 | 43636 | 100.0 | 43636 | 100.0 | 43636 | 100.0 |

For 1990, 2000, 2010, and 2021, five major LULC types (cropland, vegetation, settlement, grassland, and shrubland) were classified. The result reveals that there is a recent land-use change, especially in cropland and vegetation cover.

The LULC classification result shows that cropland increased from 45.2 % in 1990 to 57.4 % in 2000 and 58.4 % in 2010, but it decreased to 38.1 % in 2021. On the contrary, the vegetation cover decreased from 23.8 % in 1990 to 17. 1% in 2000 and 16.8% in 2010, but it increased from 16.8% in 2010 to 26.5% in 2021. According to our observation and the focus group discussion result, the highest proportion of the vegetation cover in the Senan district is the eucalyptus plantation, which has been expanded recently.

The focus group discussion result also confirmed that a significant number of farmers has been converted their cropland into eucalyptus plantations during the last 10 years.



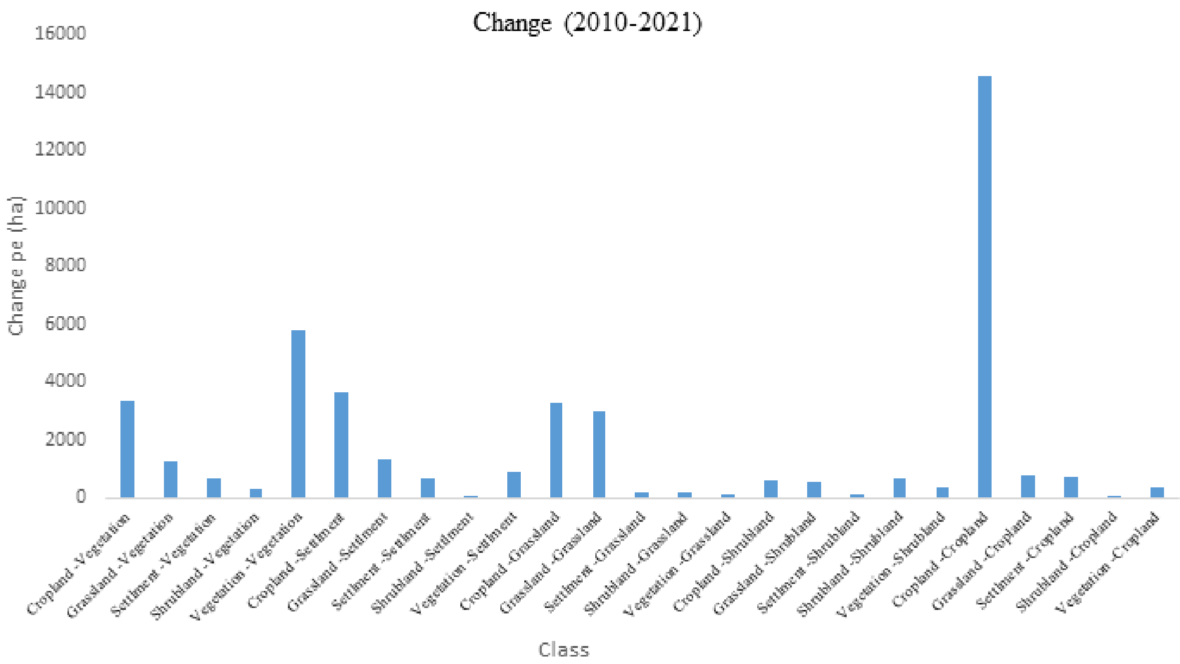




**Figure 4.** shows the calculated change detection matrix, in percent, covers the change of the whole study period from 1990 to 2021 and from 2010 to 2021

The change matrix (1990-2021) shows that the highest proportion of land was converted from cropland to vegetation. This change is mainly because farmers have changed their farmland into eucalyptus plantations. From 2010 to 2021, the conversion of cropland to vegetation experienced the most significant rate of change, with a total of 3,353 hectares, equivalent to 13% of the initial cropland, transformed into vegetation. Based on personal observation, almost all forests of the area are Eucalyptus. The key informant interview also approved that farmers are aware of the economic advantage of eucalyptus and tried to cover their cropland with this plant.

## 3.2 Factors Affecting Eucalyptus Tree Plantation

### Binary logit model result

**Table 5.** Llogistic regression results

| Explanatory variables | B | S.E. | Wald | Sig. | Exp(B) |
|---|---|---|---|---|---|
| Sex of household head | -.185 | 1.091 | .029 | .865 | .831 |
| Age of household head | .169 | .031 | 29.382 | .000*** | 1.184 |
| Marital status | 5.701 | 6.104 | .872 | .350 | 299.189 |
| Educational Status | -1.730 | .465 | 13.833 | .000*** | .177 |
| Livestock ownership (TLU) | -.385 | .140 | 7.601 | .006*** | .681 |
| Farm size in hectare | 3.039 | .548 | 30.766 | .000*** | 20.883 |
| Family size (adult equivalent) | -.957 | .203 | 22.203 | .000*** | .384 |
| Farm fertility | -2.204 | .497 | 19.665 | .000*** | .110 |
| Membership of cooperatives | .363 | .604 | .362 | .548 | 1.438 |
| Having savings | 1.453 | .432 | 11.300 | .001*** | .234 |
| Access to saving and credit service | .850 | .449 | 3.583 | .058 | 2.340 |
| Constant | -8.738 | 6.409 | 1.859 | .173 | .000 |

Land Use and Land Cover (LULC) are influenced by a variety of factors, encompassing both natural processes and human activities (Terefe *et al.* 2019). We categorized the driving factors and implications of land use land cover change and expansion of eucalyptus plantations in the Senan district into four broad categories based on the result of the binary logistic regression model, the focus group discussion, and key informant interview result, as described below.

## 3.3 Socio-demographic Characteristics

Studies by Gebreegziabher *et al.* (2010), Tegegne *et al.* (2018), and Zenebe *et al.* (2020) have all found that age, gender, and education are factors that increase the likelihood and number of trees planted by farmers. However, according to Arragaw and Woldeamlak's (2018) findings, tree-planting activity is negatively influenced by the education level of the household. On the other hand, Tefera and Kassa (2016) noted that household size has a positive and significant influence on the adoption of eucalyptus plantations by farmers. In relation to this, the binary logit results of this study show that the age of the household head positively and significantly affected the eucalyptus plantation, while family size of smallholder and educational status had a significant negative effect on the eucalyptus plantation. This result means that as the age of the household head increases, the likelihood of adopting a eucalyptus plantation also increases by a factor of 1.18. The key informant interview also reveals that farmers' motivation and decision to plant eucalyptus trees increases as their age increases. This is because tree planting does not require much labor force. Therefore, elders prefer to plant eucalyptus trees to practice crop production. Furthermore, since eucalyptus plantations do not demand more labor than crop production, female-headed households in the study area prefer planting eucalyptus to crop production.

According to the binary logistic regression model, the exp (b) value for family size is 0.38, indicating that the odds of adopting the eucalyptus plantation decrease by a factor of 0.38 for every one-unit increase in family size. The focus group discussions also revealed that farmers with large families are less likely to plant eucalyptus trees, which negatively affects their decision-making. In contrast, households with fewer family members tend to use their farmlands to grow eucalyptus because it is less labor-intensive than crop production. However, one of the key informant interviewees noted that even households with large families experience labor constraints due to increasing school enrolment rates in the Senan district, which has led to a shift towards eucalyptus plantations that require less labor. This finding aligns with previous studies, such as Asabneh *et al.* (2023), which found that family size has a detrimental impact on adopting eucalyptus tree plantations.

Based on the results of the focus group discussions and key informant interviews, it was found that female-headed households with smaller family sizes tended to choose eucalyptus planting over other crops due to its low labor requirements. A widow female-headed household also stated 'My husband was a hard-working farmer who was capable of working day and night. But after I lost him, I turned the cropland into the eucalyptus plantation because no one can help me on the farm.

### 3.4 Economic Drivers

The decision-making process of farmers regarding eucalyptus tree planting is influenced by resource ownership, including access to land, labor, livestock, agricultural inputs, and market opportunities. Asabeneh and Yoseph (2022) stated that planting eucalyptus trees offers a considerably better return on investment than growing crops and raising animals.

Other previous studies, (Kebede, 2017; Setiye & Mulatu, 2016; Zenebe *et al.*, 2020; Dereje *et al.*, 2011), However, it was underlined that a farmers' decision to grow eucalyptus trees is largely influenced by the area of their farmland. The number of cattle that households possessed significantly decreased their likelihood of working in eucalyptus plantations, according to Gebreegziabher *et al.* (2010). Eucalyptus plantations were positively and significantly impacted by total land size and savings, whereas livestock ownership had a negative impact, according to the results of the binary logistic regression model in the research region.

According to the odds ratio between livestock ownership and farm size, smallholder farmers' decision to adopt a eucalyptus plantation decreases by a factor of 0.68 as livestock ownership increases by one, while the likelihood of eucalyptus plantation increases by a factor of 20.8 as household farm size increases by one, all other things being equal.

Interviewees also reported that farmers with a large number of cattle do not have eucalyptus plantations because eucalyptus trees are not used for animal grazing, unlike crop residues. As Setiye and Mulatu (2016) described the farmers who have small landholdings prefer to produce crops and other purposes like growing fruits and vegetables than growing eucalyptus trees. The family who has a large landholding uses their land for diversifying the source of income like growing crops, fruit, tree planting, vegetables, and animal rearing.

Farmers may choose to plant eucalyptus on marginal land that has limited potential for crop production. The binary logistic regression model and focus group discussions indicate that farmers are less likely to adopt eucalyptus plantations on highly fertile land. Moreover, one of the interviewees said that

"*I do have four temad (one hectar) land. The two temad are very fertile but the remaining two temad are not suitable for crop production. That's why I planted eucalyptus trees on the plot of land which is not fertile*."

The findings of the focus group discussion revealed that farmers plant eucalyptus to make a lot of money at a time so that they will be able to either construct a house, pay school fees to their children, or move to urban areas.

Moreover, Belay *et al.* (2021) also revealed that the growing need for fuelwood, construction, and cash for various purposes are the primary economic drivers behind the planting of eucalyptus plantations.

### 3.5 Environmental Drivers

In Ethiopia's Amhara Region, Senan is one of the areas that is primarily Dega and unsuitable for growing valuable commodities like teff. Therefore, the farmers preferred to plant eucalyptus than to produce low-value products like potatoes.

Moreover, according to Yusuf (2016), Tola (2010), and Dereje *et al.* (2011) land degradation and depletion of natural vegetation are also the driving factors of eucalyptus plantations. The key informant interviewees described that land degradation is the most common problem in the district, which is usually related to soil acidity. Concerning this, Hailu and Getachew (2011) stated that Ethiopia's highland areas are experiencing an increase in soil acidity. These issues are the result of continuous cropping and the use of acidifying fertilizers. The logit result reveals that farm fertility level and eucalyptus plantation have a negative and significant relationship. According to the interview and focus group discussion, reduced crop yield because of declining soil fertility made farmers convert their cropland into eucalyptus plantations.

### 3.6 Properties of the Eucalyptus Species

According to Tefera and Kassa (2017), coppicing ability, straight pole growth, quick growth and thus shorter maturity period, multiple uses of the wood, low labor required for management, and drought, disease, and pest resistance are important characteristics of the species. These characteristics are also one of the farmers' driving factors in planting eucalyptus in the Senan district. One of the interviewees stated that

"*Eucalyptus is a good species because it saves my time and labor; it teaches me to save a lot of money; it is free from natural hazards; unlike crops, it is not consumed by animals which make it easy to have the plantation*."

The focus group discussion participants also stated that shorter growing seasons and higher biomass, increasing price of farm input such as fertilizer and improved seed, the negative effects of nearby eucalyptus plantation shades on a crop, and other farmers' successful experiences are some of the factors related to the properties of the species.

In relation to this, an interviewee emphasized that "*the shade of my neighbors' eucalyptus plantation on my cropland affects its productivity. Hence, I was obligated to convert my cropland into a eucalyptus plantation even though I did not want to do that*."

Silenat and Fikadu (2018) also stated that eucalyptus plants are typically taller than other plants of equal age due to their rapid growth, and their shade may affect nearby crops by reducing the sunlight required for growth. Moreover, Gashaw *et al* (2023) described that the detrimental effects that eucalyptus plantations have on nearby cropland made farmers convert their cropland into eucalyptus tree plantations.

## 4 Conclusion

The results indicated a decline in cropland area from 58.4% in 2010 to 38.1% in 2021, while there was an increase in vegetation cover, primarily eucalyptus, from 16.8% to 26.5% over the same time frame. This is mainly caused by socio-demographic characteristics of the household, economic factors, environmental factors, and the characteristics of the eucalyptus species, such as the availability of large plots of land for ownership, infertile agricultural land, a small labor force, a shorter growing period, the species' shading impacts, and easily accessible market opportunities are responsible for the rapid expansion of eucalyptus plantation in the study area. As a result, agricultural experts should provide support to farmers through various land-use planning strategies that take into account their socio-demographic, economic, and environmental elements and the country's land-use policy. Moreover, comparative studies should be conducted to make sure the livelihood of farmers is improved due to eucalyptus plantations.

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### Conflict of Interest

No conflicts of interest are disclosed by the authors.

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