Expansion of Accacian Decurrens tree plantation on cultivated land in Fagita Lekoma District, Northwestern of Ethiopia

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Abstract

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Expansion of *Accacian Decurrens* tree plantation on cultivated land in Fagita Lekoma District, Northwestern of Ethiopia

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Keywords: Tree plantation; Land use change; Cultivated land; Accacian decurrens; Forestland.

1. Introduction

Ethiopians face rapid deforestation and degradation of land resources. Rapid population growth has led to extensive deforestation for agricultural use, overgrazing, and exploitation of existing forests for fuelwood, fodder, and building materials (Getahun, 2015; Bishaw et al., 2019; Wassie, 2020; Yigezu Wendimu & Wendimu, 2021). In addition, most of Ethiopia's population is found in the highlands, with the North Central Massifs and the Shewa Plateau, which are often the oldest populated area in the country and the most exploited and most polluting (Hurni et al., 2005). Rapid population growth is the main cause of changes in land use leading to increased human needs for food, Fiber and fuel (Bewket & Abebe, 2013; Hurni et al., 2005; Worku et al., 2021). To meet these needs, large areas of agricultural and marginal lands are being farmed intensively, natural forests are under severe deforestation, and large areas of grazing lands are being overgrazed and degraded (Bewket, 2002; Hurni et al., 2005; Kitina Nyamasyo & Odiara Kihima, 2014). Lack of well-defined policies and weak institutional enforcement may also lead to inappropriate land use(Ariti et al., 2019; Kasimbazi, 2017; Lambin et al., 2003; Meyfroidt & Lambin, 2011).

The country's forest areas have been reduced over the past 40 years to an estimated less than 3% today. The present rate of clearing forest is estimated at 160,000 to 200,000 hectares per year. It is estimated that one billion cubic meters of fertile land are lost each year (Eshetu, 2014; FAO, 1985; Wassie, 2020), causing massive environmental degradation and posing a serious threat to sustainable agriculture and forestry. To reduce these problems, rural afforestation and nature conservation programs have been practiced on farms and communal lands in Ethiopia for three decades (FAO, 1993; G. Dessie & Erkossa, 2011; Worku et al., 2021). These plantations are mainly composed of exotic tree species, such as Eucalyptus spp., Cupressus lusitanica, Acacia decurrens and Pinus spp. These species have been chosen due to their fast growth, and attractive economic returns (Tadesse et al., 2015)

Forest plantations are a widespread economic activity in the Ethiopian highlands, mainly due to the degradation and limited access to natural forests, the introduction and popularization of fast-growing tree species, and the awareness of smallholder farmers of the economic benefits of the plantations. The expansion of forest plantations in the Amhara region occurs in different ways, such as at the private, municipal, and national levels (Dessie et al., 2011; Tadesse et al., 2015).

The current trend towards the expansion of small-scale tree plantations in the country and especially in the Amhara region also shows the acceptance of forest plantations as an attractive business for small farmers at the regional and district level (Tadesse et al., 2015, 2019). The economic potential of the tree species *Accacian Decurrens* has led to the expansion of tree plantations not only on agricultural land, but also the conversion of grass/border areas into forest areas. (Alemayehu, 2015; Wondie & Mekuria, 2018; Bishaw et al., 2019; Chanie & Abewa, 2021; Worku et al., 2021). Smallholder farmers are the main actors in the *Accacian Decurrens* tree plantation growth and commercialization systems in the district (Chanie & Abewa, 2021; Nigussie et al., 2021). Consequently, private small-scale plantations constitute by far the large Proportion of the *Accacian Decurrens* tree plantation resources accounting for more than 90% of the overall plantation area of the district (Wondie & Mekuria, 2018; Chanie & Abewa, 2021).

Land-use change from cultivated land to *Accacian Decurrens* tree plantation is an active implementation in the northwestern highland of Ethiopia particularly the Fagita Lekoma district and its surrounding districts (Alemayehu, 2015; Chanie & Abewa, 2021; Worku et al., 2021). *Accacian Decurrens* has the potential to improve soil fertility, mitigate climate change through carbon sequestration, and have economic benefits from both the annual harvest and *Accacian* Decurrens charcoal production systems (Chanie & Abewa, 2021).

In the Fagita Lekoma District, the recent history through the intervention of local government and the purposeful of communities started to cover their land by vegetation especially *Accacian decurrens* tree plantation as local people investment throughout the district. This expansion of tree plantation is taken as the initial issue of land uses change and has implications on the cultivated land, environment, and economic income of the local individual communities. Therefore, the main objectives of this study were (i) to examine the magnitude and rate of the current status of Accacian decurrens expansion; (ii) to identify the driving force of the communities to shifting cultivated land to tree plantation land use/smallholder farmers are engaging to Accacian decurrens tree productions/; (iii) to evaluate its economic benefit to the local communities and (iv) to assess its problems and opportunities for the sustainable future tree plant production in the study area.

1. **Materials and Methods**

    (a) **Geographical location of the study area**

This study was conducted in the Fagita Lekoma district in the Northwestern highlands of Ethiopia. Astronomically, the study area is located between 10° 57 23 - 11° 11 21 N and 36° 40 01 -37° 05 21 E (Fig. 1). Relatively, it is bordered on the south by Banja Shekudad, on the west by Guangua, on the north by Dangila, and on the east by the Mirab Gojjam Zone, in Awi Zone of Amhara National Regional State. It is located about 460 km northwest of Addis Ababa and 100 km southwest of Bahir Dar, the capital of the regional state of Amhara. The district covers a total area of 67,679ha with an elevation ranging from 1880 to 2921m.a.s.l.

Fig 1 Location map of Fagita Lekoma District

1. **Satellite Image data Acquisition and Analysis**

In order to cover the intended period of study, the different type's satellite images were acquired from different types of sensors. Thus are LANDSAT Thematic mapper (TM), Enhanced Thematic Mapper Plus (ETM^+) and LANDSAT 8 (OLI) from beginning of 1986, 2002 and 2020 respectively. The images were obtained from United States Geological Survey (www.USGS.gov). It was acquired from the month of January at this time clear skies season in the region it reducing atmospheric and radiometric problems.

Table 1 the types and characteristics of the satellite images used in this study

Data type	Year	Acquisition date	Sensor	Path & Row	Resolution	Source of data
Landsat	1986	Jan 01	ETM	170/52	30M	USGS
Landsat	2002	Jan 05	ETM+	170/52	30M	USGS
Landsat	2020	Jan 16	OLI	170/52	30M	USGS

The satellite image preprocessing was implemented. Different image rectification, enhancement and classification technique was applied. It aimed to improve the ability to interpret qualitatively and quantitatively image components. Multi-temporal raw satellite data has been imported to Erdas Imagine 2014 software. After this, land use land cover change maps and land cover statistics were generated to compare the temporal change of the study area for the past 34 year by using the integrating software namely ArcGIS 10.4 and ERDAS IMAGINE 2014.

To perform the classification the maximum likelihood supervised classifier was employed. Training areas for all spectral classes were developed composing each information class to be identified by the classifier. The post-classification approach was used for mapping detailed land use land cover determination. This approach is generally considered the most obvious approach to change detection. By properly coding the classification results for times 1986, 2002 and 2020, the analysis were produced a change map showing a complete matrix of changes. The detection of post-classification changes is not necessary to normalize the data for atmospheric and sensorial differences between two dates, as the images acquired over the two years are classified separately (Singh, 1989). Accuracy assessment matrix was employed to evaluate the accuracy of the classification and determines the quality of the map extracted from remotely sensed data (Congalton & Green, 2008). The common way to represent classification accuracy is error matrix as user and producer accuracy assessment.

Change detection analysis was conducted by using post classification image comparison technique. Percentage change to determine the trend of change be calculated by (Equation 1) dividing observed change by sum of changes multiplied by 100 (Puyravaud, 2003).

Percentage of change (trend) = $\frac{\mathbf{x-y}}{\mathbf{y}}\mathbf{x\ 100}$ -------------------------------------- Equation 1

Where X= recent (later) area of land use land cover.

Y= Previous (initial) area of land use/land cover (Puyravaud, 2003).

Quantification of the rate of change has been applied to generate information about the land use/land cover change of the study area. Using the rate of change between the two periods, the rate of change per annum can also be computed by dividing it with the year difference between the two periods. The rate of change of each land use and land cover can be calculated using the following equation 2 (Hassan et al., 2016; Yesuph & Dagnew, 2019).

Rate of change in percent = $\frac{\text{observed change between two maps}}{\text{rate of time intervals}}$x 100 ------------------ --Equation 2

The key informant interviewees were employed. There were four persons were involved in this study. The land administrator and elderly persons were the main participants as the relevant data sources for this study.

Table 2 Description of land use and land cover classification in Fagita Lekoma district.

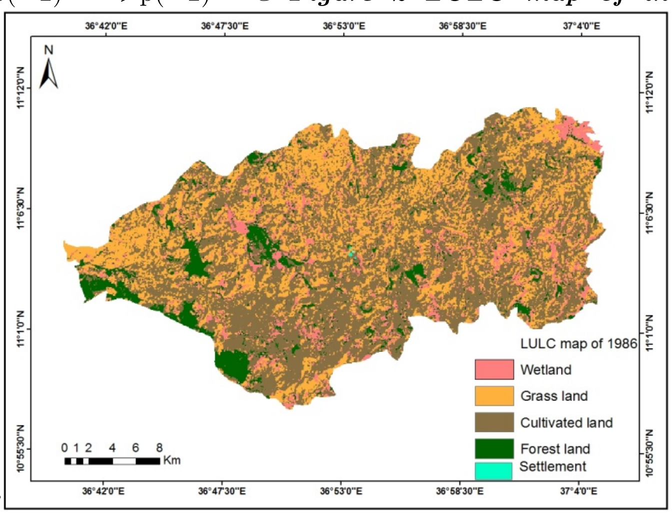
LULC class	Description
Cultivated land	Includes annual rain fed and irrigated cultivation. Lands mostly used for cereal production
Grass land	Covered mainly by grass, there is a small part of bushes and trees.
Forest land	It includes densely developed trees that form a closed canopy. The dominant tree species in
Wetland	It represents most of the flat areas where frequent flooding occurs during the rainy season a
Settlement	These areas are occupied by small towns and settlements, including markets, roads, schools

1. **Results and Discussions**

(a) **Land Use and Land Cover Change**

Based on the classification scheme (table 2) Cultivated lands, grasslands, wetlands, forestland, and settlements are the main land use land cover categories during the study period. The results of the first study period (1986) of the district (figure 2) image classification, showed that cultivated land represented the highest proportion of land in the region, with a value of (31,038 hectares), or 45.8%, followed by grasslands, which represented (28,037 hectares), 41.49%. Forestland/Plantations and wetlands accounted for 9.1% and 3.5%, respectively (table 6). Furthermore, the settlement area during this period was the smallest, with 85 hectares (0.13%).

@ >p(- 2) * >p(- 2) * @ ***Figure 2 LULC map of the study area,***



1986 & ***Figure 4 LULC map of the study area, 2020***

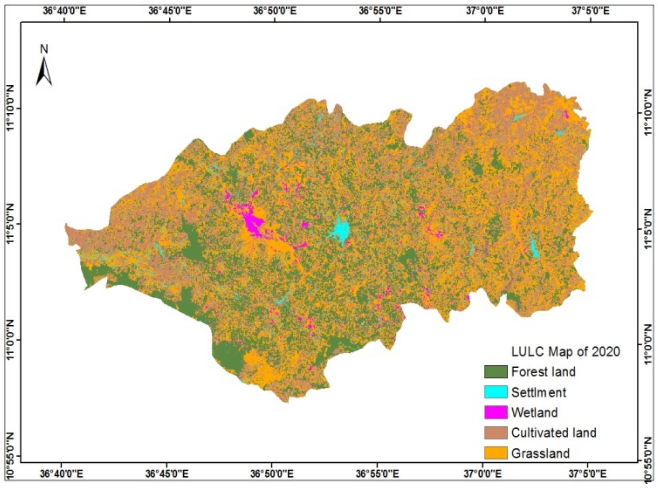
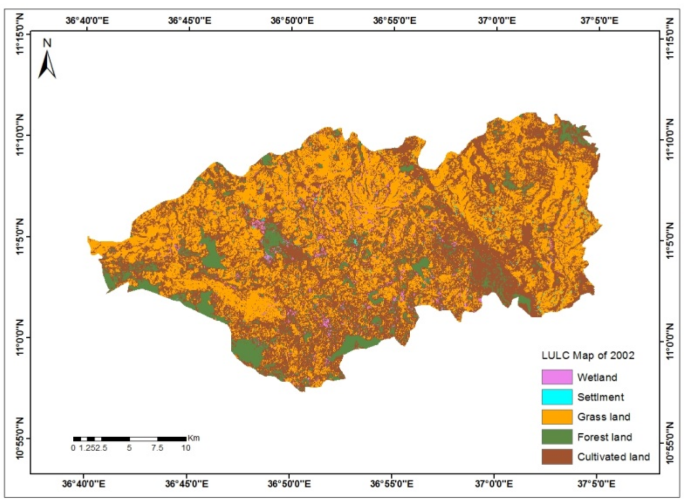
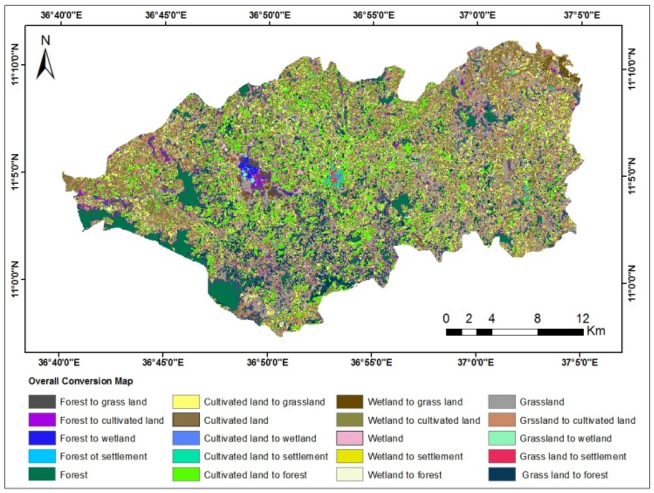


Figure 3 LULC map of the study area, 2002



& ***Figure 5***

LULC Change map between 1986-2020



In middle study period (2002) of the district (Figure 3), the proportion of cultivated land assigned increased to (35,152.56 hectares) 51.89%. In addition, the area of grasslands throughout the district has decreased, covering an area (22,535.28 hectares) of 33.26%. However, compared to the baseline study year (1986), the forest cover ratio remained unchanged at approximately (6,262.74 hectares), or 9.24% and the wetland increased slightly to (3,505.86 hectares) 5.17% (table 6). Unexpectedly, the extent of the settlements changed during the second study period. In the 1986 Landsat image, it was difficult to identify the town of Adiskidam and another area of the settlement. However, in the middle of the study period (figure 3), the town of Adiskidam achieved a decent footmark, representing only about 0.41% (280.8 hectares) of the total area of the Fagita Lekoma district.

In terms of Current land uses (2020) and land cover conditions in the study area (Figure 4), the proportion of allocated cultivated land have been significantly reduced to (24,030 hectares) 35.4%. At the same time, the area of grasslands has decreased, covering an area (22,390 hectares) of 33% (table 6). However, compared to the base year (1986) and the mean period of the study (2002), the proportion of planted forest cover increased significantly, representing approximately (19,140 hectares) 28.1%. Furthermore, the settlement area in the last 18 years has also increased, representing approximately 2.41% (1,500 hectares). Due to the area's drying up, wetlands only represented 1.3% of the 894 hectares that the area covers.

Table 4 Post-classification Matrix of the Study Area 1986-2002

Conversion matrix of 1986 to 2002	2002					
	Forestland ha	Cultivated %	Grassland ha	Wetland %	Settlement Ha	%

Conversion matrix of 1986 to 2002	2002					
1986	Forestland	3260.1	4.81	2338.2	3.45	319.05
	Cultivated	580.86	0.85	14666.5	21.65	14574
	Grassland	1987.6	2.93	17493.5	25.82	7128.6
	Wetland	414.8	0.6	795.9	1.1	482.2
	Settlement	0	0	0	0	0

Note: *Figures in* ***Shaded number*** *represent LULC that showed* ***no change.***

1. **Patterns of LULC change in the study area**

Table 6 shows the pattern of change in LULC from 1986 to 2020. Agriculture has always been the most important force for the transformation of the land on this planet. Today, almost a third of the earth's surface is used to cultivate or herd livestock (Kanianska, 2016; Yigezu Wendimu & Wendimu, 2021). Most of the agricultural land is at the expense of natural forests, grasslands and wetlands. These forests, grasslands, and wetlands provide valuable habitats for species and valuable services for humans (Kitina Nyamasyo & Odiara Kihima, 2014; Stave et al., n.d.).

In table 6 the cultivated land constituted 45.8%, 51.9%, and 35.4% from the total area of the district in the years 1986, 2002, and 2020 respectively. The still now, cultivated land use is predominate land use system in the study area. This result agrees with the findings of Zeleke & Hurni, (2001) in the Anjeni area of the northwestern highland of Ethiopia. And, A related study conducted by (Alemayehu, 2015; Worku et al., 2021) in the Fagita Lekoma district reported that cultivated land was the dominant land use type which covers 58%, 63%, and 57% for the years 1973, 1987, and 2015; and 46.3%, 30.3%, and 39.16% for the year 2000, 2010, 2017 respectively. Moreover, this result is also in line with the findings of Wubie et al. (2016) in which cultivated land was the major land-use type which covers 75.2%, 91.7% and 96.5% for the respective year of 1957, 1987 and 2005 in the Gumara watershed of Lake Tana basin, Northwestern Ethiopia.

Table 5 Post-classification Matrix of the Study Area 2002–2020

Conversion matrix of 2002-2020	2020						
	Forestland	Cultivated	Grassland	Wetland	Settlement		
	ha	%	ha	%	ha	%	ha
2002	Forestland	3,865	5.7	871	1.34	1,328	2
	Cultivated	8,993.2	13.2	11,567	17	13,820	20
	Grassland	5,761.8	8.44	10,057	14.8	6,102	9
	Wetland	418	0.61	1,535	2.26	1,140	1.
	Settlement	102	0.15	0	0	0	0

Note*: Figures in* ***Shaded number*** *represent LULC that showed* ***no change.***

In the first study period, cultivated land increased by 4,114 ha (13.3%), while it decreased by 11,122 ha (33%) in the middle study period. This result is also in line with the findings of Bewket, (2002) at Chemoga Watershed under Blue Nile Basin in the study year between 1957 and 1998 was a similar expansion and shrinking pattern of cultivated lands by 13% increase in 1957-1982, while 2% decrease in 1982-1998.

Table 6 the Post-classification Matrix of the study area (1986-2020)

@ >p(- 22) * >p(- 22) * >p(- 22) * >p(- 22) * >p(- 22) * >p(- 22) * >p(- 22) * >p(- 22) * >p(- 22) * >p(- 22) * >p(- 22) * >p(- 22) * @ Conversion matrix of 1986-2020 & 2020 & & & & & & & & & &
& Forestland & Cultivated & Grassland & Wetland & Settlement & & & & & &
& ha & % & ha & % & ha & % & ha & % & ha & % &

1986

& Forestland & 3,359 & 4.94 & 867 & 1.3 & 1,889 & 2.8 & 208.8 & 0.31 & 58 & 0.09
& Cultivated & 10,182 & 15.1 & 13,988 & 20.6 & 5,936.5 & 8.76 & 101 & 0.15 & 833 & 1.23
& Grassland & 5,286 & 7.8 & 8,325 & 12.3 & 13,610.5 & 20.1 & 299.2 & 0.44 & 516 & 0.76
& Wetland & 313 & 0.45 & 838 & 1.2 & 954 & 1.4 & 285 & 0.41 & 20 & 0.03
& Settlement & 0 & 0 & 12 & 0.02 & 0 & 0 & 0 & 0 & 73 & 0.11

Note*: Figures in* ***Shaded number*** *represent LULC that showed* ***no change****.*

The grassland covers 41.5%, 33.2% and 32.9% form the total area of the district in the years 1986, 2002 and 2020 respectively (table 6). It is the second largest land cover class in the study area. The result is in line with the finding of Alemayehu (2015); Worku et al., (2021) in Fagita Lekoma district stated that grassland land was the second largest land cover type which covers 15.8%, 32.3% and 22.7 % for the of year 1973, 1987 and 2015; and 16.5%, 18.96%, and 25.27% for the year 2000, 2010, 2017 respectively. During the overall study period (1986-2020), the conversion of cultivated land into grassland accounted for 8.76%. The reverse, grassland also loses 12.3% of its areal extent to cultivated land (table 5 and figure5). Throughout the study period (1986 to 2020) the areal coverage of grassland was decreased by 20.1% (table 6). Major reason for the decreasing of grassland was the increment population number in the area. The same time, increasing the demand of cultivated lands and contributed its share the reduction of grassland. This result is disagrees with the finding of Zeleke & Hurni (2001); Worku et al., (2021) they showed the rising of grassland coverage during the course of the study period in Anjeni area and Fagita Lekoma district respectively in northwestern Ethiopia. On the other hand, agrees with the find of Bewket (2002); Ayalew (2008); Ali, (2009); Wubie et al., (2016) Shrub-grasslands was showed a decrease of this land cover type in Chemoga watershed, between 1957 and 1998; a similar pattern of change and decreased between 1972 and 2004 in the upper Dijo River catchment; 31.1%, 23.8% and 21.8% for the of year 1973, 1986 and 2000 at Dessie Zuria district; and 2.69%, 1.36%, and 0.65% for the year 1957, 1987, 2005 in Gumara watershed respectively. In addition, the afforestation programs in the study area contributed its share for the reduction of grassland during the second study period (2002-2020), which shares 8.44% from the total area (table 4). This is due to the farmers are giving more attentions for covering their lands and surroundings by Accacian decurrens trees.

The area under forestland cover was 9.1%, 9.24% and 28.1% from the total area of the district in the year of 1986, 2002 and 2020 respectively (table 6). The rate of change forestland cover was showed relatively no more change in first study period (1986-2002) which accounts about 1.3% added on the previous. As the same way, highly increased between 2002-2020 (second study period) which accounts about 206% and 1986 and 2020 (the overall study period) was similarly to the first and second study period which was increasing about 210% from the total area (table 6). The result is in line with the finding of Alemayehu (2015); Worku et al. (2021)that was reported the increasing of forestland due to the expansion of new tree plantation in the study area. The major cause to change forestland cover in between 2002-2020 has been fundamentally by the introduction of *Acacia decurrens*. This result declined with the finding of Nigatu (2014); Wubie et al. (2016) that was reported the forest cover were becoming to reduce in the Denki river catchment nearby Ankober district; and Gumara watershed of lake Tana basin, Northwestern Ethiopia respectively. An attempt to recover the lost forest cover through afforestation program was practiced in the area during the second study period. As a result the coverage of forest vastly increased between 2002 and 2020 (the second study period) and the whole study period (1986 and 2020).

Table 7 Pattern of LULC changes between 1986 and 2020 in the Fagita Lekoma District.

LULC classes	Area 1986	Area 2002	Area 2020	Change between 1986-2002	Change between 2002-202
	ha	%	Ha	%	ha
Forestland	6,182	9.1	6,262	9.24	19,140
Cultivated	31,038	45.8	35,152	51.9	24,030
Grassland	28,037	41.5	22,535	33.2	22,390
Wetland	2,410	3.5	3,506	5.1	894
Settlement	85	0.13	281	0.41	1,500

N.B* ‘-’ *indicates decrease* ‘+’ *indicates increase* ‘ha’ *indicates hectares

Wetland is the second smallest land cover type in the study area, it was cover about 3.5% in 1986, 5.41% in 2002. However, it was decreasing and become to cover only 1.43% in 2020. By considering the overall study periods 40%, 34.6 %, 13.1% and 1.5% was converted into grassland, cultivated land, forest and settlement respectively (table 3 and table 4). It is clearly shown on Zimbiri area which is the widest wetland located on the western part of the study area. This types of land is most productive of ecosystems on earth, they are also the most threatened (Kingsford et al., 2016b; Xu et al., 2019; Schlesinger & Bernhardt, 2020) Conversion of record wetlands to cultivated land is because wetlands have the capacity to grow crops without irrigation in winter season locally known as *Borshesh* (Alemayehu, 2015). The major crops which are cultivated on wetland in study site are potato, wheat and maize. This LULC type is found around the plain areas of the landscape, which is more preferable for farming.

In the 1986 study period the settlement area covers about 85 ha (0.13%). Also in the 2002 middle study period settlement area covered 280.8 ha (0.41%) and 1,500 ha (2.4%) of the study area in 2020. The land use and land cover change between on the first study period (1986- 2002) settlement area have been expanded on cultivated land and grassland respectively (table 3 and table 4). The conversion of cultivated land and grassland to the expanse of settlement area is high. (Alemayehu, 2015; Worku et al., 2021; Wubie et al., 2016) similar results were reported, which shows the rising of settlement area due to the cause of population growth and other factors.

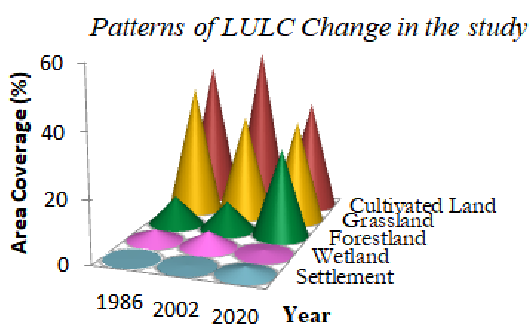


Figure 6 shows Patterns of land use/cover change in the study area.

1. **Accuracy Assessment for LULC Classification**

Land Cover Classification accuracy assessment is commonly defined as the degree to which the derived classification agrees with reality and the accuracy of the map in a larger part determines the usefulness of the map (Anderson et al., 1976; Foody, 2002; Congalton & Green, 2008). Error matrix is the most common way to present the accuracy of the classification results Overall accuracy, user's and producer's accuracies, and Kappa statistics were computed from the error matrix for each year by using equation 3 (Lillesand et al., 2004).

$$K_{hat} = \frac{N \sum_{i=1}^{r} X_{ii} - \sum_{i=1}^{r} (X_{i+} * X_{+i})}{N^2 - \sum_{i=1}^{r} (X_{i+} * X_{+i})}$$ --Equation 3

Where, Khat= kappa coefficient; N is the total number of values; $N \sum_{i=1}^{r} X_{ii}$ is observed accuracy; and $\sum_{i=1}^{r} (X_{i+} * X_{+i})$ is chance accuracy.

Overall accuracy is computed by dividing the total number of correctly classified pixels by the total number of reference pixels. User's accuracy refers to the number of correctly classified pixels in each class divided by the total number of pixels that were classified in that category of the classified image. Producer's accuracy refers to the number of correctly classified pixels in each class divided by the total number of pixels in the reference data category (Anderson et al., 1976; Foody, 2002)

Accuracy assessment is used to determine the correctness of the classified image. In this study, the accuracy assessment is performed for 1986, 2002, and 2020 classified images using ground control points collected using a topographic map, knowledge from the elderly, field visits, and Google earth pro data sets. The overall accuracy of the three classified images is shown in Table 7. The classification's overall accuracy for the years 1986, 2002, and 2020 is 89.8%, 86.7%, and 87.9%, respectively, with kappa values of 0.82, 0.85 and 0.84. The accuracy statistics and kappa coefficient values presented in (table 7) are well above the recommended values (Congalton & Green, 2019).

Table 7 LULC classification accuracy assessment results

Land cover class	1986	2002	2020		
	User accuracy%	Producer accuracy%	User accuracy%	Producer accuracy%	User a
Forestland	93.3	93.3	91.7	91.7	92.3
Cultivated land	92.94	90.8	89	94.8	84
Grassland	85	91.07	88.7	84.6	92.5
Wetland	87.5	77.78	83.3	76.9	92.9
Settlement	85.2	87.4	83.3	90.9	77.4
Overall accuracy	89.8	89.8	86.7	86.7	87.9
Kappa Statistics	0.82	0.82	0.85	0.85	0.84

1. **Rate of tree plantations expansion on agricultural land**

The possibility of switching from one land-use system to another depends on demographic changes and the economic and financial returns of the selected farm enterprises (Wondie & Mekuria, 2018). Most rural residents in the Ethiopian highlands provide more land for crop production than other land-use systems to support and feed their families. In the second study period (2002-2020), the conversion of cultivated land by 8,993.2 ha (13.2%) was observed into forestland (table 4). Accacian decurrens tree growing have taken the first responsibility to decrease cultivated land in the study area.

Table 8 Annual rates of land use and land cover change in Fagita Lekoma district.

LULC classes	Change between 1986-2002	Annual rate of change (1986-2002)	Change between 2002-2020
	ha	%	ha/yr
Forestland	+80	+1.3	+5
Cultivated	+4,114	+13.3	+257
Grassland	-5,502	-19.6	-344
Wetland	+1,096	+45.5	+68.5
Settlement	+196	+231	+12.3

***N.B* '-'** *indicates decrease* **'+'** *indicates increase* **'ha'** *indicates hectares* **'yr'** *indicates year*

The average annual rate of change (table 6 and 8) in forestland/tree plantation cover showed relatively no more change between the first study period (1986-2002), which accounts for about 0.08% added on the previous, and incredibly increased between the second study period (2002-2020) which accounts about 11.4% and the overall study period (1986-2020) was similarly increasing about 6.2% of the total area. The increase in forestland in the study area from 2002 to 2020 (table 4) is in sharp contrast with the trend in most rural areas of Ethiopia.

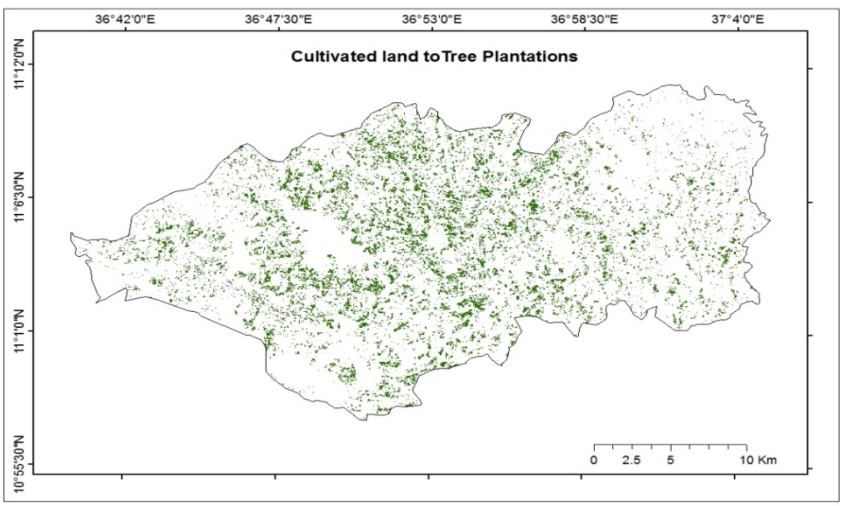


Figure 7 shows the spreading of the Accacian decurrens plantation on the cultivated land.

1. **Driving force of small holder farmers to engagement in Accacian decurrens tree productions**

1. **Increasing the actual and potential income generations**

Forest resources are one of financial assets and basic economic activities like that of animal husbandry and crop production(Jagger & Pender, 2003; Descheemaeker et al., 2009; Davies et al., 2010). In line with this literature, the expansion of *Accacian decurrens* tree plantation is fastly implemented by the serious private campaign of local farmers in between last decade in the study area (Nigussie et al., 2021; Worku et al., 2021). According to first-hand data, compared with other products, the income potential of plantation products is by far the most important driving factor for large-scale producer families. Due to the growing demand for Accacian Decurrens products (charcoal, firewood, organic ingredients, feed...), small farmers planted the Accacian Decurrens tree; it is also a potential income-generating activity in the market-driven in the study area.

1. **Adaptability and Compatibility with the other land uses**

The individual land owners is adopted a technique of *Accacian Decurrens* tree plantation together with crops such as wheat, teff, maize and green pepper during the first growing season (Tadesse et al., 2015; Ali et al., 2020; Chanie & Abewa, 2021; Nigussie et al., 2021). After harvesting the crops, the farmers left the trees to grow. Planted trees had a high rate of survival. According to local farmers, plantations are ready for harvesting 5-6 years after planting. Farmers uproot the tree at the time of harvest, so that cereal crops can be grown for one or two years before the area is replanted with *Accacian Decurrens*.

@ >p(- 2) * >p(- 2) * @

1. Time of preparation for charcol production

&

1. Farmland after tree resource harvest

1. Land getting ready for intercropping *(trees and crops)*

&

1. After intercropping (crop harvested)

Source: the photo taken by Tesfahun during field survey, 2020

1. **Declining agricultural land productivities**

The soil of Fagita Lekoma District is particularly acidic and degraded because of soil erosion and over-exploitation of cultivated land for extraordinary crop production like that of the various highland regions of Ethiopia(Wondie & Mekuria, 2018). Soil acidity is caused by the decline in agricultural productivity in the study area. This enforces farmers to grow tree plants that can tolerate soil acidity, restore soil fertility and generate additional income and jobs for the household.

1. **Job opportunities**

Previously, in the Fagita Lekoma district, many young people, including farmers, were unemployed and exposed to illegal activities. In addition, they are temporary workers who have migrated to the Kolla area in large numbers (Alemayehu, 2015; Chanie & Abewa, 2021)**.** However, thanks to the planting of golden trees, its history has created huge employment opportunities of all genders and ages. According to the actual evidence, if the future land use will be planned properly, this is a very good job creation opportunity for young people. *Accacian Decurrens* growers employ many workers on their families in the process of planting, harvesting, charcoal manufacturing, transportation and storage. In addition, there are many brokers for the *Accacian Decurrens* plantation and marketing system, including the sale of the entire plantation to Charcoal Marketing.

1. **Economic benefits of tree plantations for Local Communities**

The economic benefits of growing trees are allegedly higher than cultivating annual crops (A. B. Dessie et al., 2019; Tadesse et al., 2015). The farmers are well aware of the multiple socioeconomic advantages of *Accacian decurrens*, compared to Eucalyptus globulus and another tree species commonly planted in the study area(Wondie & Mekuria, 2018). The major objective of the *Accacian decurrens* plantation is to generate income by selling charcoal. Farmers were fortified to plant *Accacian decurrens* due to its fast growth; its use as fuel wood; its potential to be used for charcoal; its role in soil fertility maintenance; and the marketability of this species (Tadesse et al., 2015; Alemayehu, 2015; Chanie & Abewa, 2021; Worku et al., 2021). Smallholder tree planting has provided occasional employment opportunities for jobless youths and women.

According to Tesfahun (2018) reported that the mean annual income of the local farmers get 7,185 ETB from the sole of grassland use system; 31,048 Ethiopia Birr (ETB) from sole crops(cultivated land use); 68,300 ETB from sole of charcoal (forestland use). *Accacian decurrens* tree plantation growing period is in between five to six years. The result shows that the tree plantation land use provided 2.2 times more income than the sole cultivated land use system. The *Accacian decurrens* (forest) land use system provided 9.5 times more income for farmers compared with the sole grassland use system. Similar studies was conducted by Worku et al. (2021) in the study area, that reported to *Accacian decurrens* intercropped land use system provided 1.3 times more income than the sole Teff land use system. The pasture and *Accacian decurrens* intercropped land use system provided 11 times more income for farmers compared with the sole pasture land use system. The smallholder farmers obtained the greatest income from the sole *Accacian decurrens* land use system followed by the crop and the grass based land use systems, respectively. This is the main reason that motivated farmers to change the land use system from crop based land use to plantation based land use system.

1. **Opportunities and Threats of Acacia Decurrens tree Production in the study area**

Interviews with key informants demonstrated that the expansion of plantations in the Accacian decurrens in degraded landscapes, creating more jobs for landless youth and providing opportunities to diversify livelihoods, as discussed in terms of economic benefits. It is favored by smallholder farmers, due to its fast growth and good adaptability to different land-use systems in the study area. Trees are planted after clearing or on agricultural lands that have been used for other purposes. This is a new agricultural system and its practices show the potential to maximize benefits by incorporating fast-growing plants in annual crops in the study area.

However, it can also lead to a decrease in agricultural output, as it leads to a reduction in arable land, as noted above. According to the explanation of the district Cadastral Department (2020), the major problem of farmers in the study area is the lack of arable land and the decrease in agricultural production. This is demonstrated by having to import grain from neighboring districts in order to survive there food security. Currently, population pressure is high, so the need for additional land is increasing because growing of tree plantations requires more land than other land use systems. Currently due to severe land shortage, some kebeles in the district donate land to landless youth on community-owned land by organizing themselves into small business groups.

Moreover, farmers are planting fertile and irrigable lands with tree plantations attracted via way of means of profits acquired from the plantation that have to be allotted for annual crops. Farmers and charcoal makers noticeably perceived that the smoke of charcoal and its manner is dangerous for human health mainly for people who make charcoal in conventional ways. Tree plantation is a long-time period funding that wishes capital until it matures for harvest. Therefore, it makes it hard for poor smallholder farmers to use it and forced them to hire their land for wealthy people.

1. **Conclusion**

Agroforestry is a land use and management system in which trees are planted around or between crops or pastures. In the study area, the production of acacia trees is mainly extended to farmers' arable land, which may be due to the attractive economic income of tree production compared with crop production.

The results show that the area of cultivated land has been reduced by 22.6% compared to the previous coverage. The pattern of change for grasslands and wetlands is similar, with a decrease of 20.1% and 63%, respectively, 34 years ago. In contrast, the plantation forest cover rate showed the opposite trend increasing by 210%. Furthermore, the settlement area also showed a pattern of change similar to that of forest lands and increased by 1,665% throughout the study period. The pattern of land use and land cover change shows a tendency for more land to be included in forest lands due to tree planting and afforestation. Compared to the previous period, the large amount of cultivated land and grasslands covered areas were reduced and turned into man-made forests and settlement areas.

Decreasing the productivity of arable land due to the extensively cultivated and highly degradation of soil following these events the introduction of new tree plantations and the expansion of Accacian decurrens is the major responsibility to change the land-use system in the study area. As result, the increasing level of income, soil restoration through reducing soil erosion and regulating water availability, multifunctional for crop production and animal grazing with tree plantation, create job opportunities for job and landless people without age and sex specification and Possibility of reduced chemicals inputs on the plots of farmland in the study area.

As for recommendations, the federal and local governments must implement appropriate land-use policies and adopt advanced technology to process tree plantation products. Because the local farmers are using their fertile and irrigable land for tree plantation. Furthermore, farmers and charcoal makers are highly vulnerable to the smoke of charcoal and the environment is dangerous for human health, mainly for people who make charcoal in conventional methods.

Declarations

Not Applicable

- **Ethics approval and consent to participate**

Not applicable

- **Consent for publication**

Not applicable

- **Availability of data and materials**

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

- **Competing interests**

The author declares that they have no competing interests.

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- **Author contribution**

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