Journal of Agriculture and Environment for International Development - JAEID 2024, 118 (2): 5 – 28
DOI: 10.36253/jaeid-12260

Large-scale Commercial Agricultural Investment: Implications for Land Use/Land Cover Dynamics in Guba District, Northwest Ethiopia

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Submitted on: 2021, 2 November; accepted on 2024, 16 September. Section: Research Papers

Abstract: Large-Scale Commercial Agricultural Investment (LSCAI) is expected to improve the living conditions of host communities while ensuring the productive use of natural resources. However, its impact on the local environment and land use/land cover (LULC) dynamics was not well investigated in Guba District, northwest Ethiopia. This study aimed to examine the implications of LSCAI projects on LULC change dynamics. To achieve this, the study employed a concurrent triangulation design, combining of qualitative and quantitative data. Data for the study were collected from primary and secondary sources, including satellite images with ground verification. The LULC map was prepared and image classification conducted by employing Arc GIS10.5 and ERDAS 2014. Structured interviews were conducted with 351 households, and unstructured in-depth interviews were conducted with key informants. The study revealed a significant increase in LULC over time. Dense forest cover decreased by 0.61% and open woodlands decreased by 1.25% per year. In contrast, cropland expanded by 1.79% per year between 1990 and 2019. Particularly, between 2010 and 2019, the rate of cropland expansion reached 3.25% per year due to the influx of LSCAI projects. This indicates that the expansion of LSCAI projects has nearly doubled the rate of LULC change in the study area. During the key informant interviews, it was confirmed that the period from 2010 to 2019 witnessed substantial expansion of LSCAI projects in the study area. Local communities also expressed concerns about the potential threats posed by LSCAI, including deforestation, land dispossession, malpractices, violent conflicts, and increased charcoal production. The main drivers of severe LULC are anthropogenic factors that promote the expansion of LSCAI. It is recommended that in the process of LSCAI, land identification and transfer to developers should be done in consultation with local communities, and the policy direction on natural resource utilization should be revisited to ensure the most sustainable use of land resources.

Keywords: Land use, land cover, Large-scale commercial agricultural investment, Northwest Ethiopia

List of Abbreviations

BGR: Benishangul-Gumuz Region
EIA: Environmental Impact Assessment
EMP: Environmental Management Plan
FDI: Foreign Direct Investment
GERD: Grand Ethiopian Renaissance Dam
LSCAI: Large-scale Commercial Agricultural Investment
LULC: Land Use/Land Cover
NDVI: Normalized Difference Vegetation Index

Introduction

The rapid expansion of large-scale commercial agricultural investments in developing countries, particularly in sub-Saharan Africa, has raised concerns regarding their impact on land use and land cover (LULC) dynamics. These investments, often fueled by global corporations and wealthy governments, involve the conversion of significant amounts of land for agriculture, often at the expense of natural habitats like forests, grasslands, and wetlands (Yesuph & Dagnew, 2019; Teklemariam et al., 2016). This rapid and extensive change in land cover poses threats to the global environment (Worku et al., 2014).

The driving forces behind land use or land cover (LULC) change play a significant role in shaping landscapes and are defined as "the forces that cause observed LULC changes" (Schneeberger et al., 2007). This concept has the potential to serve as a theoretical framework for understanding and analyzing changes in order to identify common land-use trends. Accordingly, changes in LULC for a specific area may occur due to interactions among various environmental, demographic, and socioeconomic forces (Bewket, 2002; Mwathi, 2016). Understanding the drivers of LULC changes is crucial for modeling future dynamics and preventing further depletion of natural resources (Kindu et al., 2015).

Ethiopia has experienced significant changes in its landscape, particularly in the Benishangul-Gumuz Region (BGR) and other major river basins, due to large-scale commercial agricultural investments (Yesuph & Dagnew, 2019; Keeley et al., 2019). The Ethiopian government has promoted these investments as a means to modernize the agricultural sector and improve the lives of local communities. However, there has been considerable debate regarding the benefits of these investments, with concerns about their environmental and social impacts (Guyalo et al., 2022; Keeley et al., 2019).

In recent decades, Ethiopia has placed significant emphasis on promoting large-scale investment to achieve economic development targets, in addition to designing strategies to increase the productivity of smallholder farmers (MoARD, 2009). As a result, large-scale commercial agricultural investment (LSCAI) projects have seen remarkable growth, particularly in the northwestern part of the country. Consequently, large tracts of land have been allocated to LSCAI firms (Bekele, 2016; Woyesa, 2016; Moreda, 2016).

Particularly, in Guba district, the practice of transferring a large amount of forest or dense woodlands failed to notice the alternative and traditional use of land by the local community to ensure their livelihoods (Moreda, 2017). Concerning this, BOEPLA (2018) reported that out of identified potential land for commercial agricultural investments (1,149,483ha); 334,198.7 ha (about 29.07%) was transferred to potential investors in agricultural sectors in Benishangul-Gumuz Region, Ethiopia. Domestic investors and diaspora account for 94.13% and 4.92% respectively.

It thus, proves that Foreign Direct Investment (FDI) is less than 1% and land is mostly transferred to domestic and diaspora which accounted for about 99% of the land transferred. Thus, the recent wave in land-based investments has engendered much inclusive consideration, in which strong positions are taken on the impacts of such investments on the environment, livelihoods, economic growth, and conflict at local and regional levels (German et. al., 2013).

In order to ensure sustainable development, it is essential to integrate environmental concerns into development activities, programs, policies, etc. Thus, assessing the environmental and social implications of development projects facilitate the inclusion of principles of sustainable development aspiration soundness in advance. Concerning the environmental management practices of LSCAI projects in the region, out of 446 sample investment projects, 206 (46%) projects have EIA or management plan for environmental issues (EMP) and 240(54%) projects have no EIA/EMP.

This data reveals that the majority of LSCAI projects are conducting their land development activities without EIA/EMP. This practice is against EIA proclamation No-299/2002 of the country which declared that conducting EIA is mandatory for categories of projects specified to have EIA whether such projects belong to public or private bodies. With respect to Guba district, out of 167 investment projects, 101(61%) projects have no EIA/EMP. This indicates that a large-scale agricultural investment expansion in the district appears to ignore the local environmental issues.

In Guba district (Figure 1) the amount, rate, and intensity of land-use and land cover changes had been significantly variable, implying that it is dynamic, but it is not well documented. With regards to preceding research works on LULC in the study area, almost nearly all empirical studies focused on highland parts of Ethiopia. This may be based on accessibility and severity of natural resource depletion due to population pressure, urbanization, and economies of scale in highland areas. On the other hand, lowland areas have low population density, economic activities, and relatively better vegetation cover. On top of this, previous studies mostly emphasized an overview of LULC in the entire landscape of the district. They hardly ever focused on the extent to which LSCAI stimulated LULC by identifying areas that are considered hot spots concerning the over-concentration of LSCAI projects in operation.

There are still deficiencies and methodological inconsistencies in the reviewed literature. Alternative approaches to better understand the problem are vital. Hence, examining the impacts of large-scale commercial agricultural investments on land use/land cover dynamics in the Guba district of northwestern Ethiopia under different Spatio-temporal scales at a regional scale can be expected to provide insight into past, present, and future impacts of LSCAI on LULC in the study area.

As a result, there is scanty in-depth empirical study emphasizing on main driving forces and expected actors for land use and land cover change in Guba district, northwestern Ethiopia. Because of this, the study was intended to investigate the dominant driving forces for LULC changes to realize the arguments in theoretical frames and empirical evidence on drivers of LULC dynamics.

To this effect, the analysis of LULC change was made using time-series satellite images of Landsat-5 and Sentinel-2 to investigate the impacts of LSCAI on land use or land cover dynamics in Guba district, northwestern Ethiopia. Following this introduction, Section 2 presents the methods used for the study. Section 3 presents the results, while the subsequent section discusses the obtained results. Finally, the last section presents the conclusion and policy implications.

Materials and Methods

The study area description

The study was conducted in Guba district, northwestern Ethiopia. It is one of the twenty administrative districts of the Benishangul-Gumuz Region (BGR). It is also part of the Metekel Zone and is bordered by the Abay River in the south, Sudan in the west, Amhara Region in the north, and Beles River in the southeast (Figure1). The Grand Ethiopian Renaissance Dam (GERD) is located in this district. With an altitude ranging between 558 m to 2729 m above sea level, and an average daily temperature of 20–25°C, it is gifted with diverse vegetation cover. However, the majority of its area (75%) falls under the lowland category, with a maximum daily temperature of up to 34°C during the hottest periods. The mean annual precipitation ranges between 500–1800 millimeters.

The Guba district is mainly the moisture-stressed area in the Region. The district has a total population of 22,322 according to CSA (2017) projection and it is also home to diversified ethnic groups, such as Gumuz, Shinasha, Amhara, Agew, Oromo, and Tigray. The CSA information depicted that the district had an estimated population of 10,851 in 2005. This indicates the notable growth of the population (nearly more than half percent within one decade) due to the substantial flow of labor forces towards economic activities related to LSCAI projects in the district.

The main livelihood strategies of the local people are gold mining, shifting cultivation, hunting and gathering, animal rearing, and border petty trades. The study area is a destination for LSCAI projects. Thus, large tracks of agricultural land acquisition are a dominant feature of the district as well as in the BGR. According to the Regional Bureau of Land Administration and Investment (BoLAI) official report, about 167 LSCAI projects are in operation on large tracks of land in Guba district (BoLAI, 2021).

However, LSCAI projects are undertaken at the cost of local people's natural resource-based livelihood strategies which require a sufficient amount of land and related resources for shifting cultivation, free grazing, a gathering of forest-based products such as forest honey, and forest fruits, and environmental and socio-economic conditions (Mwathi, 2016). In addition, the growth of the population is a critical factor increasing pressure on the land resource in the district. This is due to the rising demand for cropland and settlement, and trees for fuel and construction purposes.

Accordingly, in the study area, the dominant factors for land use and vegetation cover changes are related to economic activities and policy direction of the country, especially for the encouragement of LSCAI. The existing large-scale investment policy direction and legal frameworks are designed in a way that motivates the potential investors' participation in agricultural sectors. Thus, this is the reason for the enormous flow of LSCAI firms in Guba district. This in turn has its implications on the present land and related resources depletion as well as LULC changes in the district under the study.

DOI: 10.36253/jaeid-12260

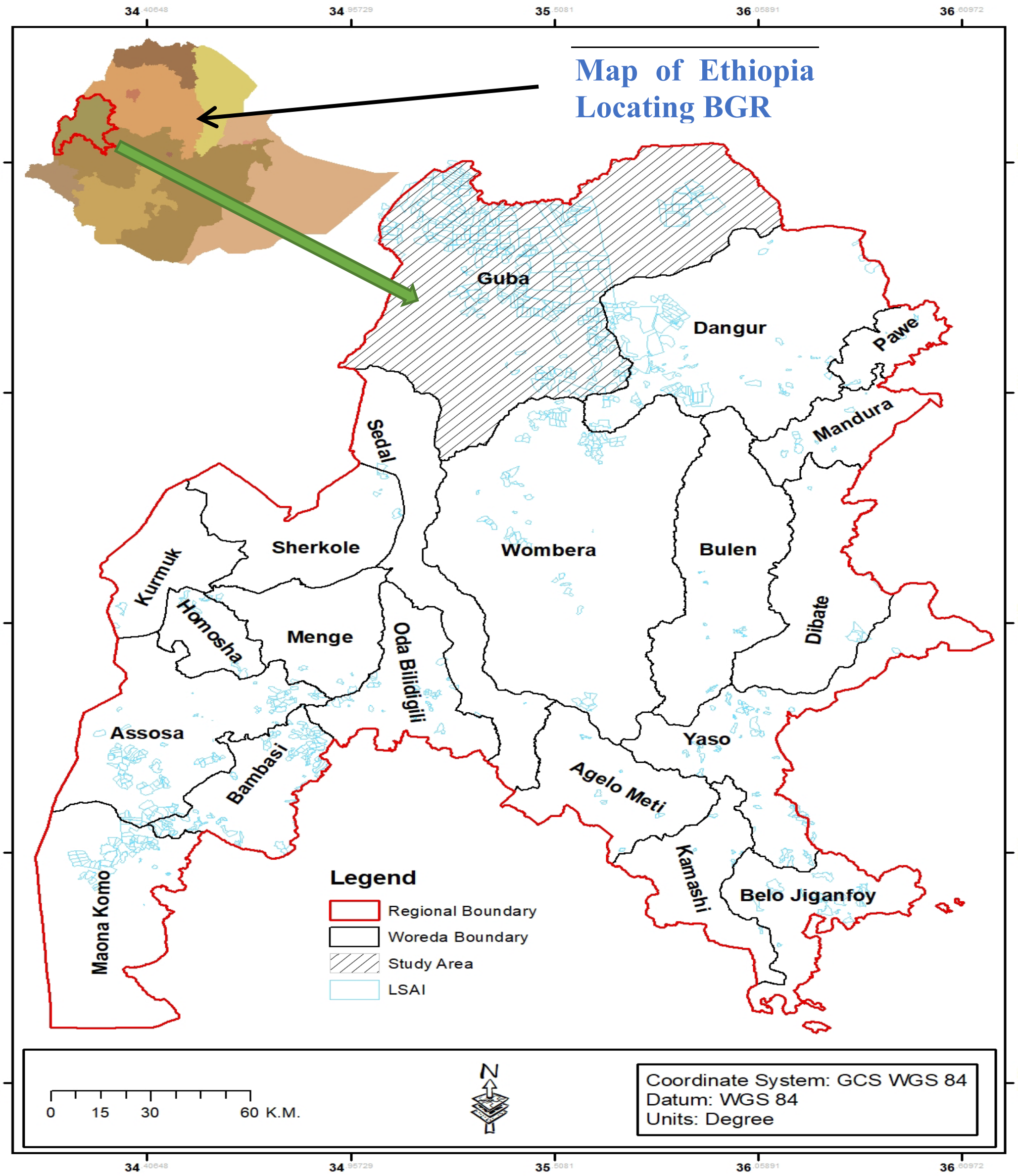

Figure - 1: Study Area Map. Source: Benishangul-Gumuz Region Bureau of Finance and economic Development (BGRBoFED) (2021).

Data acquisition and analysis methods

This study employed satellite remote sensing imageries to analyze LULC and its implication on natural resources and the environment. Remotely sensed data are widely used in LULC classification (Mishra et al, 2012). It is utilized to detect the extent to which improper land use is causing environmental degradation and devise a way for sustainable utilization of the land ecosystems (Babiso et al, 2016). Based on satellite image data (land sat5 and sentile2), land use and vegetation cover change map or image was analyzed by employing Arc GIS software to calculate the Normalized Difference Vegetation Index (NDVI). To supplement the remote sensing satellite image data, a household survey and key informant interview were conducted. Thus, methodologically the concurrent triangulation design of the mixed research approach was employed in the study. The household survey and key informant interviews were used to collect data on perception and awareness of local communities towards the main driving forces of LULC and its implication for their natural resources-based livelihoods.

The NDVI is a sensitive indicator that detects changes in plant canopy. It analyzes the red and near-infrared wavebands (Kattimani & Prasad, 2015). Remote sensing commonly uses the NDVI index to assess vegetation coverage in different areas and time periods (Singh & Javeed, 2021). It is useful for detecting changes in land cover caused by natural or human activities and analyzing spatial and temporal variations in vegetation coverage. Abdul-Hammed & Mahdi (2022) also suggested that the NDVI method is a powerful way to monitor vegetation. The NDVI is a widely used indicator in remote sensing that evaluates vegetation health and density (Singh et al., 2020). It is calculated by analyzing the reflectance values from the near-infrared (NIR) and red light bands. The formula for calculating NDVI is:

$$NDVI = \frac{NIR-RED}{NIR+RED} \qquad \text{Eq.1}$$

Where NDVI is constructed from near-infra-red (NIR) and the red band (RED). Commonly NIR stands for high vegetation cover and RED for low vegetation cover.

The assessment of land use/land cover dynamism was conducted by using time series satellite images. The data and software used for their respective purposes are presented in Table 1. The datasets can be available from two platforms, Sentinel 2 Level 2 C images were downloaded from European Space Agency (ESA) data hub (https://scihub.copernicus.eu/) and Land sat 5 Level 1 was from https://earthexplorer.usgs.gov/.

Table 1 – Data and software employed for assessment of land use or cover change

No.	Data source	Year	Spatial Resolution	Processing level	Purpose
1	Landsat-5	1990, 2000 and 2010	30m	Vegetation Discrimination (Visible Red and Near Infrared bands)	Land use/Land cover
2	Sentinel-2	2019	10m	Vegetation Discrimination (Visible Red and Near-Infrared bands)	Land use/Land cover
			Software utilized		
3	ERDAS Imagine 2014				Stack images, Subset, NDVI calculation, NDVI classification, and Accuracy assessment
4	ArcGIS10.8				Map preparation
5	Google Earth Pro 7				Ground truth collection
6	Excel 2016				Classification accuracy (Overall accuracy and Kappa coefficient)

Sources: 1. Claverie, et al., (2018); 2. Claverie, et al., (2018); and 3. Basha, et al., (2018).

The image processing and data manipulation were conducted using algorithms supplied with the ERDAS software, which also incorporates Geographical Information System (GIS) functions. Arc/Info was used for GIS overlay analyses. Change detection and monitoring involve the use of multi-date images to evaluate differences in land use and land cover due to environmental conditions and human actions between the acquisition dates of images (Singh, 1989). The image processing procedures (Figure 2) included image per-processing, the design of classification schemes, image classification, accuracy assessment, and analysis of LULC changes and dynamics of investment land expansion.

The extent of change was estimated for each LULC type by considering the amount of land area measured in hectares within a given year (ha/year).

$$Rate\ of\ change\ (RoC) = \frac{(Yc - Yp)}{Yti} \qquad \text{Eq.2}$$

Where: Yc = Current area of LU/LC in ha, Yp = Previous area of LU/LC in ha, Yti= Time interval between Yc and Yp in years.

The analysis of LULC was made using time-series satellite images of landsat5 and sentil2. Since the L-band has a canopy penetrating capacity, it is highly useful to differentiate between forest and non-forest areas. These data sets were used to improve the LULC classification results obtained from Land sat 5 TM and Sentinel 2 classifications. Remote sensing approaches are the most cost-effective means of quantifying land use and cover change over vast areas of extraordinary spatial and temporal details.

Thus, remotely sensed datasets have become increasingly available to the public at no cost. The land sat satellites are the most notable instruments that have been operational in acquiring image data of the globe on a time series basis since the 1970s. More recently, improved in its spatial, spectral, and temporal resolutions, sentinel 2 images were added up to existing public domain satellites and acquire images of the earth's surface in three spatial resolutions (10m, 20m & 60m) and with five days temporal resolution.

The study employed a post-classification comparison method to identify changes in land use and land cover (LULC) between 1990, 2000, and 2019. However, due to ongoing conflicts in the area, the study was unable to include the years 2020, 2021, and 2022, resulting in a halt in investment activities. The study measured and visually represented the extent and distribution of LULC changes in order to identify significant trends.

Results

Previous studies have primarily focused on analyzing changing trends of land use and land cover (LULC) using remote sensing satellite imagery. However, given the nature of the research problem, it is necessary to gather both quantitative and qualitative data in order to thoroughly investigate the issue. In this study, data was collected from primary and secondary sources. Additionally, structured interviews were conducted with households and key individuals to supplement the remote sensing data and provide a comprehensive understanding of the topic.

The interviews aimed to assess community perceptions regarding the main drivers of LULC change and their impact on livelihoods dependent on natural resources. One of the notable aspects of this study is that the intensity of change was calculated twice - once considering overall land use and vegetation cover, and again considering the areas recommended for the LSCAI projects. Methodologically, the study employed a concurrent triangulation design, utilizing a mixed research approach.

Land use and land cover change analysis based on time series satellite image

The land use or cover change analysis in the reference years from 1990-2010 was illustrated by Land sat 5 TM image composites, while the 2019 references were signified by Sentinel-2 images for acquiring high image resolutions. In satellite image analysis, processing image classification is a vital step to identify the land-use change in each class. In line with this, the environment, forest, and climate change commission (MoEFCC) land use classification were utilized in this study. MoEFCC (2016) categorized the board land cover classes into seven classes: forest or dense woodland, cropland, open woodland and grassland, shrubland, wetland, bare lands, and built-up areas.

Figure 2 depicts the land use or land cover conversion in the Guba district using LULC as a proxy. The analysis, therefore, used Land sat5 and sentinels 2 images of study areas acquired in four-time references 1990, 2000, 2010, and 2019 in Guba district, Benishangul-Gumuz Region.

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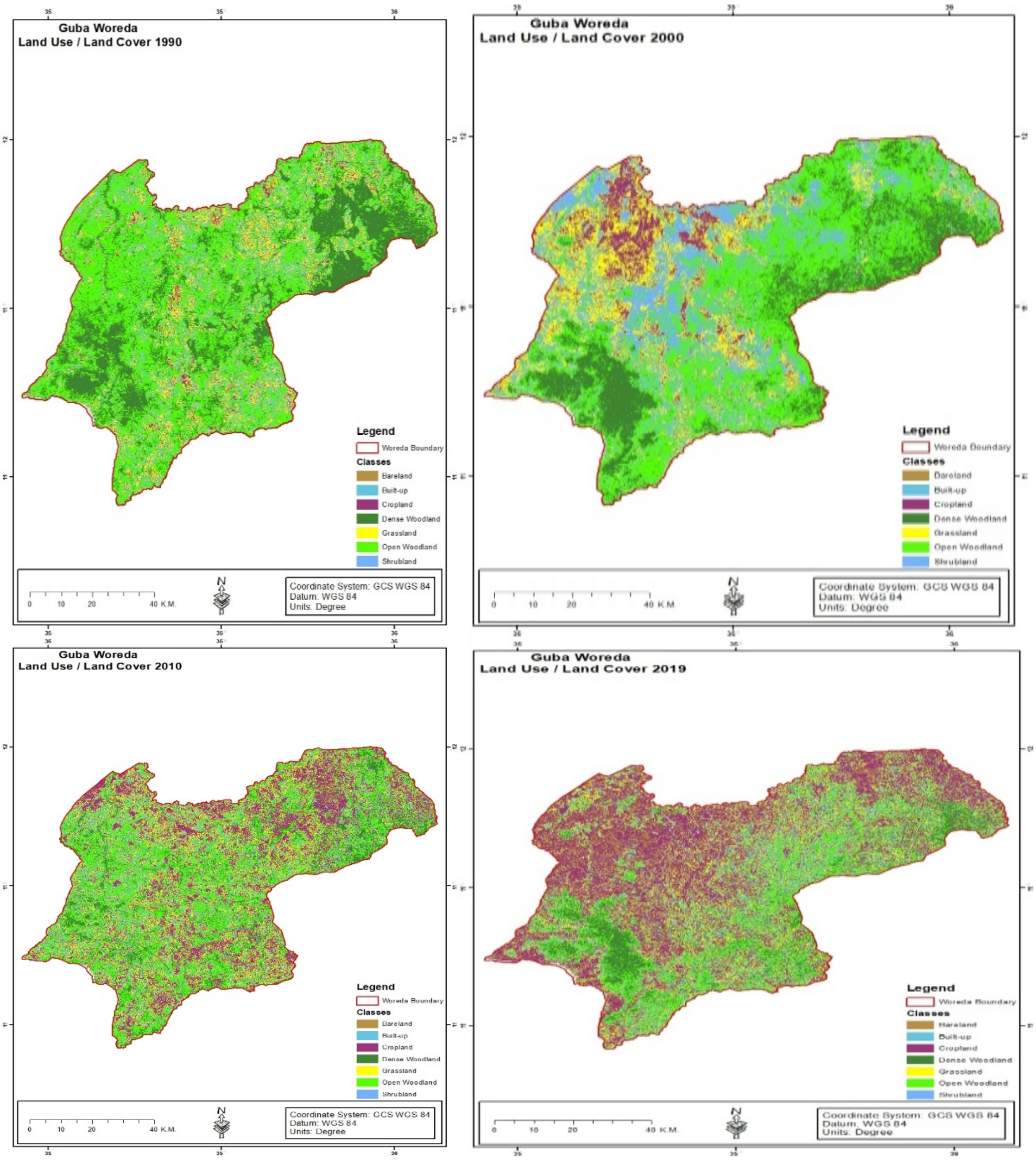

Figure 2 - LULC in Guba District, Benishangul-Gumuz Region, Northwestern Ethiopia. Source: LULC Satellite images of 1990, 2000, 2010 & 2019

As shown in Table 2, the dominant land use or land cover in 1990 was open woodland (28.35%), followed by shrubland (12.85%), and forest or dense woodland (12.50%). At this time, the share of cropland (1.61%) was very insignificant. Similarly, in 2000, the land use or land cover was predominantly open woodland (21.97%), followed by shrubland (19.86%) and forest or dense woodland (9.01%). During the same period, the share of cropland (3.37%) remained insignificant, although it did increase by 1.76% compared to the 1990 reference period.

Table 2 also shows that in 2010, the main land use or land cover was open woodland (19.14%), followed by shrubland (15.20%), cropland (11.29%), and forest or dense woodland (6.36%). This period is important for analyzing land use and land cover changes caused by LSCAI in the Guba district of the country. As depicted in Figure 2, the land use or cover change in 2019 reveals a significant shift towards croplands (18.56%). This conversion of land use led to a decrease in dense woodland, open woodland, and shrublands. Furthermore, the built-up area expanded from 28.72 hectares to 243.14 hectares between 2010 and 2019 (Table 2). This indicates that the influx of labor due to LSCAI projects in the study area is contributing to population growth and the expansion of built-up areas.

Table 2 – LULC analysis of four referenced periods (1990, 2000, 2010 & 2019) in Guba district

Land use/land cover	1990		2000		2010		2019	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Bare land	11.07	0.002	594.28	0.08	8,345.07	1.1	28,872.43	3.79
Built-up Area	20.76	0.003	25.14	0.003	28.72	0.004	243.14	0.032
Cropland	24,592.10	1.61	51,325.60	3.37	171,142.90	11.29	277,429.00	18.56
Dense Woodland	187,324.00	12.5	132,554.00	9.01	85,452.65	6.36	51,535.58	4.23
Grassland	86,300.80	6.58	115,374.00	8.62	142,577.30	11.33	139,229.13	11.95
Open Woodland	346,872.00	28.31	268,805.00	21.97	213,656.40	19.14	128,363.70	12.51
Shrub land	112,929.00	12.85	189,635.00	19.86	137,206.50	15.2	132,976.71	14.81
Waterbody	3,772.46	0.49	3,509.17	0.46	3,412.65	0.45	3,172.50	0.41
Total	761,822.19	100	761,822.19	100	761,822.19	100	761,822.19	100

The figure below, Figure 3, displays the strength and direction of the linear relationship between the extent of cropland and dense woodland (forest area) from 1990 to 2019. Both variables are strongly correlated with the overall land use and land cover (LULC) classifications. However, Figure 3 clearly shows that there is an inverse relationship between the extent of cultivated area and dense forest. This suggests that the expansion of cropland, primarily driven by the LSCAI projects, has come at the expense of forest areas.

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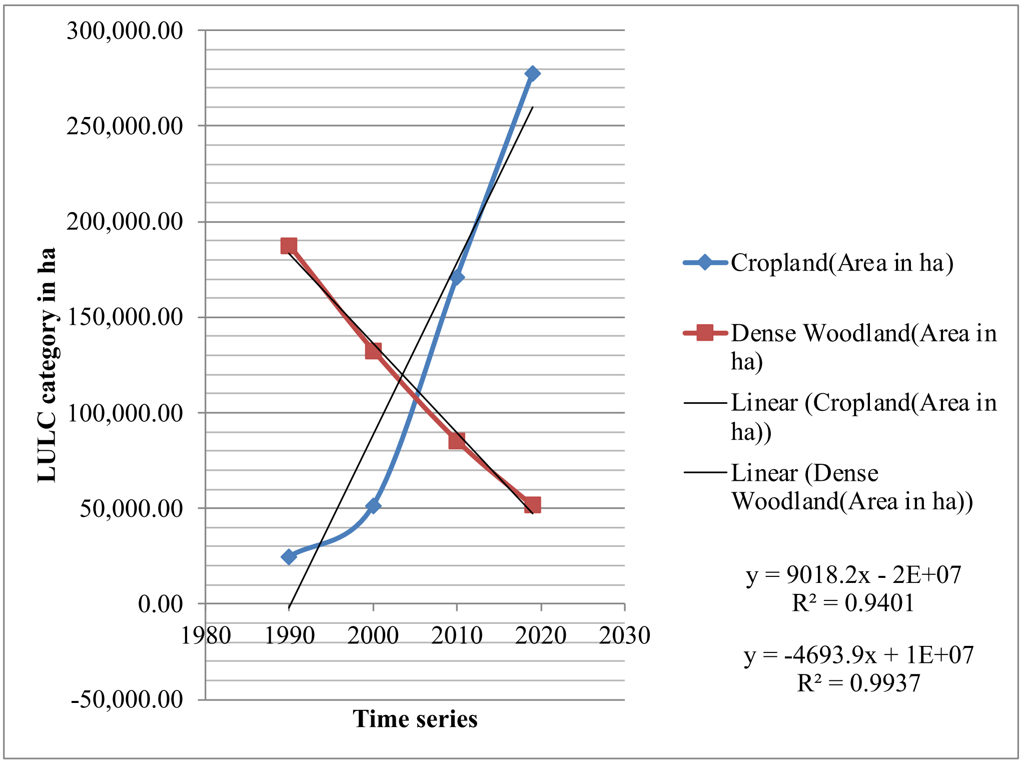

Figure 3 - Line graph on the relationship between cropland expansions and dense woodland (forest area) in (1990-2019). Source: Satellite image information (1990-2019) on LULC in Guba district

The results in Table 3 show a significant increase in cropland in the Guba District between 1990 and 2019. In 1990, cropland accounted for only 3.23% of the total area, but by 2019, it had expanded to 55.09%. This growth can be attributed to the government's support for large-scale commercial farming to promote economic development. The 1.79-fold increase in cropland area highlights the extensive expansion of agricultural land.

Over nearly three decades, the Guba District has experienced significant changes in land use and land cover dynamics. One notable transformation is the substantial expansion of cropland, which increased from around 3.23% in 1990 to an astounding 55.09% in 2019 (Table 3). This shift reflects the trend of prioritizing agricultural expansion over preserving natural ecosystems, with a focus on large-scale commercial agricultural investments (LSCAI) in the region.

In contrast, there has been a significant decrease in dense woodland areas, declining from 19.15% in 1990 to just 1.42% in 2019. This loss of dense woodlands is concerning as it reduces biodiversity and compromises important ecosystem services like carbon sequestration and soil stabilization. Open woodlands and shrublands have also experienced significant reductions, indicating a broader pattern of habitat loss. The decrease in open woodlands from 47.33% to 10.96% further highlights the pressure exerted by agricultural expansion on natural landscapes (Table 3).

The increase in bare land, from negligible amounts in 2000 to 2.88% in 2019 (Table 3), suggests that previously vegetated land is being cleared for agriculture. This trend raises concerns about land degradation and desertification, which could have long-term implications for soil health and agricultural productivity. Initially, grassland areas increased from 12.94% in 1990 to 20.85% in 2010, but then slightly declined to 15.84% by 2019. This fluctuation may indicate changes in land management practices or variations in climatic conditions that affect the viability of grasslands.

Table 3 – Analysis of LSCAI-induced LULC in Guba district (1990-2019)

Land use/land cover	1990		2000		2010		2019	
	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Bare land	-	-	497.87	0.23	2,414.37	1.12	8, 256.62	2.88
Cropland	6,976.45	3.23	28,523.85	13.19	55,946.18	25.87	157,959.90	55 .09
Dense Woodland	41,425.90	19.15	19,236.60	8.89	15,858.40	7.33	4,065.45	1.42
Grassland	27,978.80	12.94	41,413.80	19.15	45,099.80	20.85	45,413.97	15.84
Open Woodland	102,370.00	47.33	64,503.10	29.82	55,905.80	25.85	31,413.82	10.96
Shrubland	37,167.90	17.18	61,826.90	28.59	40,785.20	18.86	39,362.01	13.73
Waterbody	368.55	0.17	285.14	0.13	277.53	0.13	274.48	0.10
Total	216,287.61	100	216,287.26	100	216,287.28	100	286,746.24	100

To summarize, the satellite image analysis of LSCAI-induced land use and land cover dynamics (shown in Table 3 above) indicates that over the past 29 years, there has been a decrease of 36.37% in land areas covered by open woodlands and a decrease of 17.73% in land areas covered by forest or dense woodlands. This reduction in natural vegetation cover has the potential to impact the provision of vital ecosystem services and biodiversity in the study area.

The rate of LULC changes in referenced periods (1990-2000, 2000-2010, and 2010-2019)

The rate of LULC dynamics, in terms of overall change and LSCAI-induced LULC, suggests that cropland expansion occurs mostly at the expense of forests, dense woodlands, open woodlands, and shrublands, excluding bare land. This indicates that the study area was primarily covered by a combination of dense and open woodlands during the 1990-2000 period. The intensity of change was calculated twice, considering overall land use and vegetation cover, as well as the land and vegetation areas recommended for LSCAI projects. According to calculations, land use or land cover dynamics are increasing at an accelerated rate, particularly in the 2010-2019 periods (as shown in Table 4). Specifically, dense/forest and open woodlands decreased by an average of 0.84% per year during the 1990-2019 period, while croplands increased by an average of 0.59%. The annual rate of increment was 0.8%.

Table 4 - Rate of LULC in the referenced periods in Guba district

Land use/land cover	2019-1990	2019-2010	2010-2000	2000-1990
Bare land	0.379	0.299	0.102	0.008
Built-up Area	0.001	0.002	0.000	0.000
Cropland	0.585	0.801	0.792	0.176
Dense Woodland	-0.285	0.237	-0.265	-0.349
Grassland	0.185	0.069	0.271	0.194
Open Woodland	-0.545	-0.0737	-0.283	-0.634
Shrub land	0.068	-0.043	-0.466	0.701
Waterbody	-0.003	-0.004	-0.001	-0.003
Total	0.385	1.2873	0.15	0.093

Similarly, the area covered by dense forest decreased by 0.61% and open woodlands by 1.25%, resulting in a combined reduction of 1.86% between 1990 and 2019. Over the past 29 years, cropland expansion has increased by an average of 1.79% annually as shown in Table 5 below.

Table 5 - Rate of LULC dynamics induced by LSCAI in Guba District

Land use/land cover	2019-1990	2019-2010	2010-2000	2000-1990
Bare land	0.09	0.20	0.089	0.023
Cropland	1.79	3.25	-0.054	0.996
Dense Woodland	-0.61	-0.66	1.27	-1.061
Grassland	0.1	-0.56	0.17	0.621
Open Woodland	-1.25	-1.65	-0.397	-1.751
Shrub land	-0.12	-0.57	-0.973	1.141
Waterbody	-0.07	-0.03	0	-0.004
Total	-0.07	-0.02	0.105	-0.035

According to the LULC dynamics driven by LSCAI, the overall rate reveals that the expansion of LSCAI projects leads to a nearly 50 percent increase in the rate of land use and land coverage change in the study area. During the KII interview, the informants confirmed that the reference periods of 2010-2019 experienced a significant expansion of LSCAI projects in the district. Additionally, the 18-year average high-temperature data from the Guba district indicate a noticeable increase during similar periods (see Figure 4).

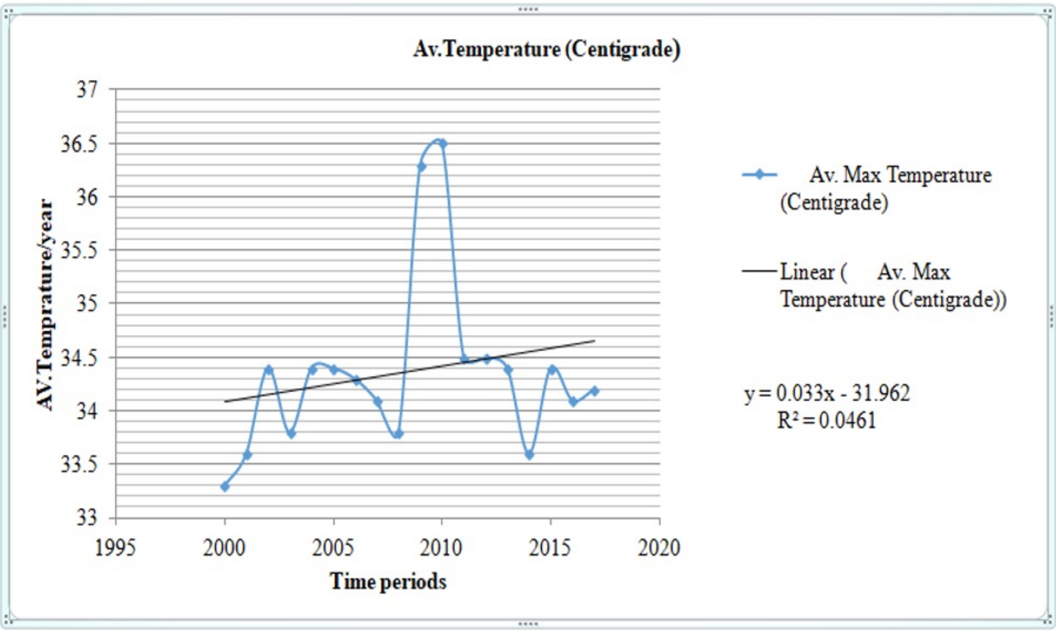

Figure 4 - Time series data on trends of temperature information (Guba district)
Source: BGR Regional Meteorology and Bureau of Agriculture and Natural Resource, 2020

Accuracy assessment of LULC map or satellite image analysis processes

As mentioned earlier, Landsat-5 satellite images were used to generate the LULC map of the study area for 1990, 2000, and 2010 referenced years while the 2019 reference year was represented by Sentinel-2 images. The image composite was classified with an overall accuracy of 87% and a kappa coefficient of 0.82 (Table 6). The satellite image analysis indicates intense LULC dynamics over the past twenty-nine years.

Table 6 - Accuracy assessment of LULC analysis

Accuracy Assignment	8	7	6	5	4	3	2	1	
Classification	Dense Woodland	Open Woodland	Shrub land	Grassland	Cropland	Bare land	Built-up	Waterbody	Total (User)
Dense Woodland	137	0	0	0	0	0	0	0	137
Open Woodland	0	15	0	0	0	0	0	0	15
Shrub land	0	0	12	0	0	0	0	0	12
Grassland	0	0	0	20	8	0	0	0	28
Cropland	0	0	0	0	170	0	0	0	170
Bare land	0	0	0	0	44	12	0	0	56
Built-up	0	0	0	0	0	2	5	1	8
Waterbody	0	0	0	0	0	0	0	12	12
Total (Producer)	137	15	12	20	222	14	5	13	438
Overall Accuracy									87
Kappa Coefficient									0.82

Perception on trends of land use land cover dynamism in Guba District

The expansion of LSCAI in the region under study in recent years has led to increased rates of natural resource depletion and occurrences of bush fires. In light of this, local communities were asked about their awareness of the status of the LULC phenomenon in their areas. The survey found that nearly all of the respondents (94.3%) agreed that LULC is increasing significantly over time. A small percentage of respondents (5.7%) disagreed with this statement. Similarly, when asked about land resource conversion in their localities, over 96% of respondents reported the conversion of forest, bush, and grassland into investment farms (as shown in Table 7 below).

Table 7 - Local communities' perception of the mode of land resource conversion in their localities

Mode of Conversion	Response	Frequency	Percent
Forest land to investment farmland	Yes	344	98
	No	7	2
	Total	351	100
Bush and grassland to investment farmland	Yes	341	97.2
	No	10	2.8
	Total	351	100
Village to investment farmland	Yes	330	94
	No	21	6
	Total	351	100
Range land to investment farmland	Yes	340	96.9
	No	11	3.1
	Total	351	100
Reserved/park area to investment farmland	Yes	302	86
	No	48	14
	Total	351	100

Moreover, during the structured interview, households were asked about the implementation of environmental conservation practices by LSCAI firms in their local areas. The results indicated that the majority (93%) of respondents reported that LSCAI firms had not engaged in any environmental conservation practices. This finding suggests that these firms do not prioritize environmental issues, and it also points to a lack of enforcement of environmental laws and a deficient monitoring system for investment projects. Additionally, the survey results reveal that LSCAI firms lack an effective Environmental Management Plan (EMP) and are not prepared to carry out the environmental conservation strategies outlined in their Environmental Impact Assessment (EIA) or EMP documents.

Potential threats of LSCAI projects to Local communities Livelihood bases

Concerning potential threats of LSCAI on local communities' livelihood bases (Table, 8), the respondents acknowledged that agricultural investment has potential threats: deforestation (86.1%), biodiversity (84.9%) dispossession of land (66.8%), increased charcoal production practices (85.2%) and increase the incidence of forest fire (82.6%). However, significant numbers of respondents stated that LSCAI intervention does not affect the dispossession of land (29.7%). This discrepancy may be due to a misunderstanding among local communities about the definition of land dispossession, which can include the loss of communal lands and related resources. Therefore, those respondents who confirm the absence of land dispossession induced by LSCAI expansion may only be referring to the dispossession of their own farmland and homesteads. However, it should be noted that this definition can also encompass farmlands, homesteads, rangelands, forestlands, wetlands, and other communally-used land resources.

Furthermore, based on the mean score of the survey results, the potential threats posed by LSCAI can be ranked as follows: malpractices, deforestation, biodiversity loss, violent conflicts, forest fires, charcoal production, and the depletion of wetlands. This indicates that the mean score results are closely related to the practical challenges faced by the host communities and the extent of vegetation cover change in the vicinity of LSCAI projects. These findings also support the correlation between LULC dynamics caused by LSCAI and the recurring violent conflicts in the study area, particularly in the localities where LSCAI projects are concentrated. However, it is worth noting that variables such as walking distance for obtaining water and firewood appear to be less affected by the expansion of LSCAI in the study area at present. This suggests that the LSCAI project areas still possess significant natural resources that can benefit the communities, despite the severe degradation caused by these projects.

Table 8 - Potential threats of LSCAI on local communities' livelihood bases

Items	N	SD (%)	D (%)	Indf (%)	A (%)	SA (%)	Mean	Std. Dev
Deforestation	351	4.3	8.3	1.4	27.1	59	4.28	1.115
Biodiversity loss	351	3.7	10	1.4	32.8	52.1	4.20	1.110
Depletion of wetland & water sources	351	4.3	6.3	1.7	55	32.8	4.06	.990
Dispossession of land	351	6.8	23.9	1.4	18.8	49	3.79	1.428
Walking distance for fetching water & firewood	351	6	31.9	1.7	17.7	42.7	3.59	1.449
Violent conflict	351	4.3	8.3	1.7	34.5	51.3	4.20	1.099
Malpractices (rent-seeking behavior & cultural influence)	351	3.4	6.6	1.4	28.8	59.8	4.35	1.031
Increase charcoal production practices	351	4.6	9.1	1.1	35.3	49.9	4.17	1.123
Increase the incidence of forest fire	351	2.6	13.4	1.4	27.9	54.7	4.19	1.138

Note: SD: Strongly Disagree, D: Disagree, Indf: Indifference, A: Agree, and SA: Strongly Agree

In short, the study revealed a significant increase in LULC changes over time, with a decrease in dense forest (0.61%) and open woodlands (1.25%) per year, and an expansion of croplands (1.79%) per year between 1990 and 2019. From 2010 to 2019, the rate of cropland expansion increased to 3.25% per year, mainly due to LSCAI projects. This indicates that LSCAI projects have caused almost half of the LULC changes in the study area. During interviews with key informants, it was confirmed that there was a significant expansion of LSCAI projects in the study area from 2010 to 2019. Local communities also expressed concerns about deforestation, land dispossession, malpractices, violent conflicts, and increased charcoal production as potential threats from LSCAI.

Discussion

This study examined the effects of Large-Scale Commercial Agricultural Investment (LSCAI) projects on land use and land cover dynamics in the Guba district of northwest

Ethiopia. The study found that between 1990 and 2019, there was a significant increase in land use/land cover (LULC), with a decrease in dense forest and open woodlands, and an expansion of croplands. In particular, the period from 2010 to 2019 indicated a rapid increase in cropland due to LSCAI projects.

This expansion of LSCAI projects in the area has led to concerns about deforestation, land dispossession, malpractices, conflicts, and increased charcoal production. The study also found that the transformation of the landscape is influenced by both human activities and climate change factors. Another study conducted in a watershed identified seven major LULC classes and found significant transitions due to human activities and natural factors (Yesuph & Dagnew, 2019) .The most notable change in the Guba district was the continuous expansion of farmland and settlements, resulting in natural resource depletion and bush fires.

The analysis of satellite images showed a decrease in open woodlands and dense woodlands over the past 29 years, confirming earlier research findings. Dense woodland decreased from 187,324.00 hectares (12.5%) in 1990 to 51,535.58 hectares (4.23%) in 2019. Similarly, open woodland decreased from 346,872.00 hectares (28.31%) to 128,363.70 hectares (12.51%). The loss of natural vegetation can have negative impacts on biodiversity and ecosystem services. These findings are consistent with a study conducted by Alemu et al. (2020) which revealed that the forest cover in the BGR decreased from 11.4% in the 1990s to 6.8% in the 2010s, primarily due to land conversion for commercial agriculture. Likewise, Temesgen et al. (2014) highlighted the widespread conversion of land for agriculture in lowland areas of Ethiopia, including the BGR, resulting in the loss of natural habitats and ecosystem services (Muluneh & Arnalds, 2015).

On top of this, other studies have reported transformations in cropland, grassland, and other land cover types (Guyu and Aduwa, 2020). Previous studies (Guyu and Aduwa, 2020) have reported similar findings, showing a significant change in dense forests (29 percent) and open forests (18 percent) over a 30-year period. The overall rate of change in land use and land cover, driven by LSCAI projects, is significant. The expansion of these projects increased the rate of change by 50% in the study area, leading to a decline in forest cover and an increase in croplands. These findings are supported by studies (Leul et al.,2023; Bessie et al.,2014; and GIZ, 2018) that have identified anthropogenic and natural factors as causes of forest degradation and an increase in croplands. These results align with the findings of Worku (2014), who also observed a notable change in cropland, grassland, mixed cover, and shrubland. Specifically, cropland in Southern Ethiopia experienced a considerable increase from 23.33 percent to 31 percent between 1986 and 2006.

Over the years, the bare land areas in the study region have significantly grown. In 1990, only 11.07 hectares, or 0.002% of the total land area, were bare. However, by 2019, the amount of bare land had expanded dramatically to 28,872.43 hectares, accounting for 3.79% of the total land area. These results support previous studies that have identified certain areas experiencing degradation or reduced productivity due to intensive agriculture or other factors (Temesgen et al., 2014; Gebreselassie et al., 2016; and Marru & Weldegebriel, 2021). This highlights the importance of implementing sustainable land management practices to preserve soil fertility and prevent further degradation.

The built-up areas in the region have significantly expanded over the years. In 1990, it covered 20.76 hectares (0.003% of the total area), but by 2019, it had expanded to 243.14 hectares (0.032%). This indicates that the investments made in the region may have led to the development of infrastructure and settlements. This supports the theoretical notion that there is a massive flow of labor forces towards economic activities (Portes & Walton, 2013; Sassen, 1990 and Temesgen et al., 2021). Consequently, the influx of labor due to LSCAI projects in the study area is contributing to population growth and the expansion of built-up areas.

The study also found that LSCAI firms lack environmental management plans and local governments do not regularly monitor their environmental practices. Contradicting a previous study (Woyessa, 2016), the majority of respondents reported land dispossession caused by LSCAI projects, indicating a misunderstanding among local communities about what constitutes land dispossession.

The potential threats of LSCAI projects include deforestation (86.1%), biodiversity (84.9%) dispossession of land (66.8%), increased charcoal production practices (85.2%), increase the incidence of forest fire (82.6%), violent conflict(85.8). This result aligns with a study conducted by Müller et al. (2021) that found large-scale land deals encroach upon natural ecosystems and shared land resources, leading to significant deforestation, loss of wildlife habitats, ecosystem services, and local livelihoods.

Contrary to the findings of Woyessa (2016) study, which concluded that there is no land dispossession caused by LSCAI in the study area, the survey results reveal a different perspective from the majority. This discrepancy may be attributed to a misunderstanding among local communities regarding the definition of land dispossession, which includes the loss of communal lands and related resources. Hence, those respondents who claim the absence of land dispossession resulting from LSCAI expansion may only be referring to the dispossession of their own farmland and homesteads. However, it is important to note that the dispossession also encompasses farmlands, homesteads, rangelands, forestlands, wetlands, and other communally-used land resources.

However, variables such as access to water and firewood are currently less affected by LSCAI projects expansion. Despite the degradation caused by LSCAI projects, the study area still has potential natural resources that can benefit the communities. Factors contributing to LULC changes include drought, conflicts, resettlement, migration, land tenure reform, political changes, and economic factors. If these changes persist along with the effects of climate change, livelihoods and agricultural production will be greatly affected (Tolessa et al., 2020).

These regional trends underscore the significance of the findings in the Guba District, as they suggest that the observed changes in land use and land cover are part of a larger transformation driven by extensive LSCAI projects in the BGR. In line with this, the study's findings suggest that the swift conversion of land for agriculture has led to the degradation of natural habitats, loss of ecosystem services, and disruption of local livelihoods. These impacts could potentially undermine the long-term sustainability of land and vegetation covers in the region. Consequently, there may be trade-offs between LSCAI projects and the sustainable management of the environment.

Overall, this study highlights the importance of combining satellite imagery and local perceptions to understand the impact of LULC on environmental sustainability. It is significant for developing policies and strategies to tackle global sustainability challenges. The study area is situated in the heart of the Nile river basin, where the ongoing construction of the Grand Ethiopian Renaissance Dam (GERD) necessitates sustainable vegetation covers to ensure the provision of ecosystem services for downstream countries. Therefore, it is crucial to acknowledge the social, economic, environmental, and political challenges faced by countries in the Nile river basin and involve long-term decision-makers to promote cooperation among these nations.

In accordance with this study, scientific communities worldwide continue to affirm that the primary cause of changes in land use and land cover is the expansion of agricultural land, particularly in developing countries. This aligns with both theoretical and empirical evidence regarding the factors driving these changes in specific regions. Additionally, they agree that if these trends persist, dense and open woodlands are likely to be significantly reduced in the near future. This has serious implications for the livelihoods and environment of local communities, as they heavily rely on forests and other natural resources in the study areas. Furthermore, the study's results confirmed the notion that land use/cover (LULC) change is a complex and dynamic process influenced by various interacting factors, including natural processes and socioeconomic dynamics. These changes have a significant impact on the structure, functions, and dynamics of landscapes. Consequently, it is crucial to monitor and map LULC dynamics to understand the environmental status and effectively manage and utilize natural resources.

Conclusions

The expansion of large scale commercial agricultural investment (LSCAI) projects in Guba District, Northwest Ethiopia, has had a significant impact on the region's land use and land cover dynamics. This study investigated the specific implication of LSCAI on changes in land use and land cover patterns over time. The study period, which spanned from 1990 to 2019, revealed significant changes in the composition of land use and land cover (LULC) in the Guba District. These changes were determined through the analysis of satellite imagery and field survey data.

In terms of the key findings of this study, there has been a significant increase in the area dedicated to cropland. Analysis of satellite imagery revealed that the cropland area expanded from 1.61% in 1990 to 18.56% in 2019. This expansion often occurred at the expense of other land cover types, particularly woodland and forest cover. Dense woodland decreased from 12.5% in 1990 to 4.23% in 2019. Similarly, open woodland decreased from 28.31% to 12.51%. The loss of natural vegetation can have negative impacts on biodiversity and ecosystem services.

The expansion of LSCAI projects increases the rate of land use or vegetation cover transition in the study areas by almost 50 percent. This has adverse implications for the livelihoods of local communities and the environment. The majority of communities heavily rely on land and natural resources for survival. The national policy to utilize large tracts of agricultural land without a land-use strategy in lowland areas, and the failure of land-related legal frameworks to accept the customary land use system, can be considered driving forces for LULC changes in Guba district, Benishangul-Gumuz Region. In addition, the actors involved, including government bodies at various levels and investors, have shown little commitment to guiding and conducting investment activities in accordance with the provisions in environmental resource frameworks.

The study findings indicate that commercial agricultural investments in Guba District have had a significant impact on land use and land cover. It is evident that there has been an increase in cropland and a decrease in woodland cover. Nevertheless, it is crucial to prioritize the sustainable implementation of these investments and evaluate the potential environmental and social effects on the local communities.

Therefore, it is important to understand the potential risks of LSCAI projects for hosting communities before proposing them in specific local areas. This understanding can help maximize the benefits of LSCAI initiatives while minimizing the negative effects on the livelihoods of local communities. It is also crucial to select capable firms to prevent illegal encroachment in forest areas and minimize disputes arising from competition for land resources.

Accordingly, this study aimed to contribute to the existing literature on the implications of LSACI projects on LULC in the Guba District. The main goal is to gain a thorough understanding of the changes in land use and land cover (LULC) in this area. To achieve this, primary data collection methods such as satellite imagery analysis and field surveys were used. This approach allows for a comprehensive and evidence-based perspective on the subject. The study area has unique characteristics in terms of transforming LULC patterns, which can lead to environmental degradation with potential impacts on the Nile River basin countries. The authors believe that the findings will inform policymakers about the importance of inter-boundary cooperation in ensuring environmental sustainability. Further in-depth studies are needed to determine the implications of LSCAI-induced LULC, particularly on one of the objectives of the Grand Ethiopian Renaissance Dam (GERD), which is to ensure regulated water flow downstream in the Nile basin countries by managing sedimentation problems.

Acknowledgments

Our thanks go to the Benishangul-Gumuz region (Ethiopia) and the Ethiopian Civil Service University for allowing us to pursue this study, without which this achievement would not have been possible. We would like to thank all institutions and individuals at the national, regional, and district levels who provided us with the information for this study.

Authors' contributions

1) The Author (Temesgen Disassa Marru) makes substantial contributions to the conception and design, and/or acquisition of data, and/or analysis and interpretation of data;

2) The Co-author (Tebarek Lika Megento) assisted in the conception and designs of the manuscript as well as in the interpretation of data, and writes up;

3) The second Co-author Amsalu Bademo Beyene revised and edited the manuscript critically for important intellectual content.

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