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Dynamics of Land Use and Land Cover Change in Bishoftu City, Oromia Regional State Ethiopia

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Abstract
This study investigates the land use and land cover (LULC) dynamics in Bishoftu City, Oromia Regional State, Ethiopia, The LULC analysis from 1990 to 2020 in the area reveals significant transformations in land use categories: cropland, vegetation, settlements, and wetlands. Initially, in 1990, cropland dominated the landscape, covering 76% of the total area, with vegetation at 14%, settlements at 6%, and wetlands at 4%. Over the three decades, cropland consistently decreased, dropping to 74% in 2000, 73% in 2010, and 64.7% by 2020. Vegetation cover also saw a decline from 14% in 1990 to 10% in 2020. In contrast, settlement areas increased substantially, from 6% in 1990 to 22.8% in 2020. Wetlands showed a minor but consistent reduction, decreasing from 4% in 1990 to 2.6% in 2020. These changes are predominantly driven by urban expansion, deforestation, agricultural activities, and economic development. Accuracy assessments of classified maps revealed high reliability, with overall accuracy ranging from 96% to 98%. The study highlights the urgent need for sustainable urban planning, reforestation efforts, wetland conservation, and effective land use regulations to mitigate adverse environmental impacts. In conclusion, the research underscores the critical role of understanding and addressing LULC dynamics for sustainable development. Recommendations include enhancing land use regulations, promoting sustainable agricultural practices, developing wetland conservation programs, and improving public awareness and education. This study provides valuable insights for policymakers and urban planners to make informed decisions and promotes sustainable land management practices in Bishoftu City.

Keywords: *Urbanization, remote sensing, satellite imagery, cropland, vegetation*

1. Introduction

LULC refers to how humans use the earth's physical landscape together, and changes in LULC reflect how people use and operate on the land (1). Within the urban setting, the natural landscape is mostly replaced by impermeable surfaces, resulting in detrimental effects on the environment, water quality, air quality, biodiversity, microclimate, ecosystem, and hydrological processes (2). Because of these LULCC is currently global agenda. In this sense, a great deal of academics and researchers have been interested in it throughout the globe (3). In Africa, where population growth and urbanization have increased rapidly in recent decades (4), major adjustments are being made to the continent's land use(5,6). Additionally, the higher standard of life and greater employment possibilities in cities are reasons why individuals want to live there (7). The transition from wetlands to other land uses, agricultural

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land, forests, or wasteland to built-up area is going to have an effect on the region's biodiversity(8,9). This transition also results in a number of secondary problems, including pollution, urban heat islands, and water scarcity (10). Cities offer better employment opportunities.

Furthermore, these job opportunities are a result of industrialization and commercialization (11). As a result, if a new policy or any type of urban expansion is being proposed (7). The spread's characteristics and its possible future growth must be taken into account by urban planners (12,13). In recent decades, Ethiopia has undergone significant changes in land use and land cover (LULC) driven by population pressure, resettlement programs, climate change, and various human and natural factors(14). The main reason for the negative alteration of natural resources and landscapes is human activity, which adversely impacts Land use land cover (LULC) changes, driven by urbanization, deforestation, and agricultural expansion, can significantly impact biodiversity, water resources, and urban climate. Deforestation, for instance, can lead to habitat loss and fragmentation, endangering numerous species. Urbanization can alter hydrological cycles, leading to increased runoff and decreased infiltration, which can affect water availability and quality. Additionally, the replacement of natural vegetation with impervious surfaces in urban areas can contribute to the urban heat island effect, leading to higher temperatures and increased energy consumptiont (15). Accurate data on the rate of LU changes and urban expansion are crucial for sustainable development and effective natural resource management (2). Analyzing LULCC is highly valuable for understanding historical land use, predicting future changes, and identifying the processes and driving forces behind these transformations (15,16).

GIS and RS make it simple and efficient for humans to analyze and work with geographic data covering wide regions (17). For the current research, examining variables such as land use and land cover, proximity to roads, rivers, and lakes, elevation, aspect, and population density, urban studies employing RS and GIS will prove to be valuable tools(18).
In urban areas of Ethiopia, we are seeing widespread and swift changes in LULC; this may be attributing to the nation's objectives for economic change and population growth(19). The economic sectors in urban areas generate a lots of job opportunities (20). Those things attract people from rural areas who want a better life and a better career. In order to get those services, people moving from the countryside to the cities, which increases housing and infrastructure needs in urban areas. The local administration alters the land covers to address those issues (21). Research indicates that rapid urbanization, often detrimental to the environment, has resulted in decreased vegetation cover (22). This reduction has subsequently worsened land degradation, urban waterlogging, the heat island effect, and various other related problems(23,24).Particularly in developing countries, the swift speed at which of urban growth leads to faster-than-ever changes in LC and use. These transformations are frequently characterized by unchecked urban sprawl, land degradation, and the conversion of farmland to other uses, all of which significantly harm the environment(25,26). LULC map provides information to countries so that they can decide what actions to take according to the data from remote sensing (RS). Planning for land conservation, management, and development is thought to require this understanding and the ability to identify land change. Comprehending the intricacies of environmental transformation to guarantee sustainable growth and devise strategies for the most advantageous eventual utilization of these territories (27).

Bishoftu City is experiencing rapid population growth, expansion of the manufacturing and service sectors, and significant horizontal expansion due to its geographical proximity to Addis Ababa. This uncontrolled expansion has led to alarming LULCC, including a reduction in agricultural land and vegetation cover, wetland, and an increase in built-up areas. These changes pose significant challenges for sustainable urban and environmental management. Currently, there is a lack of comprehensive information on the temporal dynamics of LULCC in Bishoftu City, particularly from 1990 to 2020. Utilizing Remote Sensing (RS) and Geographic Information Systems (GIS) techniques can provide valuable insights into these changes over time. This information is crucial for developing targeted and effective policy initiatives to manage urban growth and environmental conservation(17). The aim of this study is to address this information gap by analyzing the LULCC in Bishoftu City over the past three decades.

2. Methods

Bishoftu city is located in the center portion of the Oromia Regional State and is part of the East Shewa zone, one of the state's 18 zones. Geographically located in 8.7627°N,38.9981°E. Additionally, Bishoftu city is situated southeast along the Addis Ababa-Djibouti road, 47 kilometers away from Addis Ababa. Bishoftu city occupies a geographic area of roughly 18266 hectares, based on the institute's evaluation (OUPI,). The CSO sample surveys indicate that in 1967 and 1970, Bishoftu's population was 21,220 and 27,747, respectively. The city's population increased at a considerable rate between the two decades, at 5.36 percent annually. In 1984 and 1994, the town's population increased to 55655 and 73372, respectively. There were 100,114 people living in Bishoftu city as of the 2007 census (28).

The research method of this study is primarily quantitative, supplemented by qualitative insights to enrich the understanding of LULC dynamics. The quantitative aspect involves the use of RS & GIS tools to analyze Landsat satellite images across four different time points: 1990, 2000, 2010, and 2020. Image preprocessing techniques such as contrast stretching, edge sharpening, and supervised classification using the maximum likelihood algorithm are employed to ensure high-quality, accurate LULC maps. Accuracy assessments are conducted using 100 test samples for each year to validate the classification. Qualitatively, key informant interviews with experts from various fields provide contextual understanding and supplemental data on observed LULC changes. The integration of these approaches allows for a robust analysis of land use trends, driving factors, and their implications, offering valuable insights for policymakers and urban planners. This mixed-methods approach ensures a comprehensive and nuanced understanding of the LULC changes in Bishoftu City, aligning with the study's objectives.

2.1. Research Design

The research design is a longitudinal, descriptive-analytical study aimed at understanding the dynamics of LULCC in Bishoftu City from 1990 to 2020. it incorporates both quantitative and qualitative research methods to provide a comprehensive analysis of LULC changes over a 30-year period. RS techniques form the backbone of the data collection process, utilizing Landsat satellite imagery to monitor spatial and temporal changes. The study is structured to identify, classify, and quantify different land cover classes and to analyze the driving forces behind these changes. The data is further validated using field observations and key informant interviews. The research findings are visualized through LULC maps, tables, and figures that highlight the trends and patterns observed. This design allows for a detailed examination of both historical and contemporary land use dynamics, facilitating the formulation of actionable recommendations for sustainable land management.

2.2. Data Source

This study used both primary and secondary data to meet its objective. The primary data get from KII, field observation and secondary data was obtained from satellite images.

Table 1. Remote sensing data acquisition

Data Source	Satellite	Path	Row	Spatial Resolution(meter)	Date of Acquisition
USGS	Landsat 5 TM	168	54	30X30	1990
USGS	Landsat 7 ETM+	168	54	30X30	2000
USGS	Landsat7ETM+	168	54	30X30	2010
USGS	Landsat8	168	54	30×30	2020

Source: https://earthexplorer.usgs.gov/

2.3. Sampling Methods

Various sampling methods were employed to gather past and present information for identifying the historical and recent LULCC of the study area. Time-series data for the study area were obtained from sources such as Google Earth and the USGS. To validate the anticipated results, key informant interviews were conducted with city administration workers. In this study the researcher conducted key informant interviews they were selected based on their professional expertise or firsthand experience with community issues related to land-use and cover changes. This included leaders and experts in land administration, environmental protection, natural resource management, urban agriculture, and urban greening and beautification, and the interview format was open-ended, and also to ensure the accuracy of our image classification results, we implemented a random sampling approach for accuracy assessment. This involved randomly selecting sample points across the study area, ensuring a representative coverage of different land cover types. These sample points were then used for ground truth data collection, comparing the classified images with actual LC information to assess the accuracy of the classification process.

2.4. Method and Data Analysis

Image preprocessing and enhancement For reliable data analysis and information extraction from satellite imagery, image preprocessing is necessary. Image pre-processing refers to manipulating images at their most basic level, focusing on fundamental operations. While these operations don't add new information to the image, they may reduce its overall information content, particularly when considering entropy as a measure of information. The goal of pre-processing is to enhance image data by addressing unwanted distortions and highlighting specific features that are important for subsequent processing and analysis (29). The initial step in processing image data was choosing relevant satellite imagery (30). In order for the digital images to be utilized in a GIS, it needs to be connected with similar coordinate system; the sub-set tool will be used to clip the image with the study area boundaries, and projected to UTM zone 37 N (Universal Transverse Mercator) and converting in to bands. Further crucial processing steps will be used for geometric and radiometric corrections, in order to correct distortion resulting from lens distortion, atmospheric effects, sensor location and movement, and atmospheric effects. If there are geometric distortions and radiance errors in the image every image will undergo image enhancement to improve the clarity of its details and make it easier to interpret.

According to Lin et al., (2018), Image enhancement involves improving the quality of an image to make it clearer and easier to understand for feature extraction or interpretation. This project introduces various preprocessing techniques for image transformation, such as geometric correction (image registration), atmospheric correction, and radiometric calibration. Additionally, image analysis was performed using an image analysis window, adjusting the displayed contrast, brightness, transparency, and gamma transformation of the three-year Landsat images. Beside this process Image filtering involves identifying small neighboring pixels that represent a single real object with similar or identical brightness values, and then generating a new brightness value in the resulting image (32).

2.5.Post Classification

Post-classification analysis, a common method for change detection, provides detailed LULC maps, making it a natural choice for this task (33). Emphasizes identifying differences through the comparison of independent classifications performed on imagery of the same location captured at different times (29,34,35).Post-classification filtering was generalizing the dataset by removing stray pixels in the image and producing more homogeneous class areas(30). post-classification filtering was performed after conducting supervised classification(33). Following the initial image classification, a post-classification refinement step was employed to enhance the thematic accuracy of the classified image(36). This refinement was conducted within QGIS using the Semi-Automatic Classification Plugin (SCP) and its Edit Raster tool(37). Accuracy assessment

Accuracy assessment is a crucial step that ensures the reliability of a classification derived from remote sensing data(38). It involves comparing the newly created map with a reference map that represents the actual land cover on the ground(39).
This study employed a combination of original mosaic images and Google Earth imagery to gather reference data for accuracy assessment. A total of 100 test samples were randomly chosen for each year: 1990, 2000, 2010, and 2020. This implies that the researchers used the original mosaic images from each respective year as the primary source for reference data.

2.6. Data Analysis for Driving Forces of LULC Change

Data concerning the driving force of LULC change that was collected via key informant's interviews were analyzed.

3. Result and Discussion

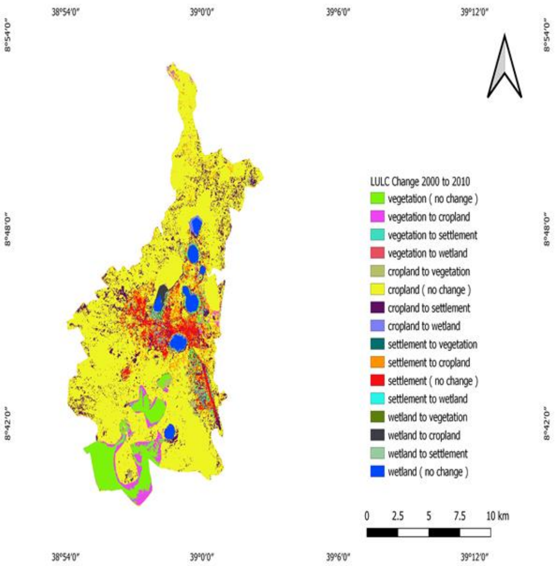

Figure 1. LULC dynamics detection map of Bishoftu city from 2000 to 2010

3.1. Cropland

In 1990, cropland was the predominant LC in the study area, encompassing 13,851.72 hectares, which is 76% of the total land area. This dominance persisted in 2000, with cropland covering 13,543.63 hectares, representing 74% of the area. Despite a slight reduction, cropland remained the largest land cover in 2010, occupying 13,432 hectares or 73% of the total area. By 2020, cropland had decreased more significantly to 11,789.09 hectares, but still covered a substantial 64.7% of the total land area. This trend indicates a gradual but notable decline in cropland over the three decades. According to the respondents the reasons behind the observed decrease in cropland stability over the past three decades (1990-2020) "Urbanization is a major factor," explained by city administration experts. According to this, the City is expanding rapidly to accommodate a growing population, and a lot of agricultural land is being changed into residential, commercial, and industrial areas. The construction of infrastructure such as roads, highways, and public facilities often takes up large areas of fertile agricultural land". Rapid expansion in Bishoftu to meet the demands of a growing population leads to the conversion of agricultural land into residential, commercial, and industrial areas. Additionally, the development of infrastructure such as roads, highways, and public facilities, while essential for progress, consumes substantial amounts of fertile farmland. Similarly, studies indicated that(40). The analysis of LULC changes demonstrated a reduction in cropland agricultural land in all years from 2,764.37 hectares (65.12%) in 2003 to 999.05 hectares (23.53%) in 2019 the decrease in cropland is significantly influenced by urbanization When cities expand, agricultural land is often converted into residential, commercial, and industrial areas. This urban growth reduces the amount of land available for farming, contributing to a decline in cropland.

3.1. Vegetation

Vegetation covered 2,551.86 hectares, or 14%, of the study area in 1990. By 2000, this had decreased to 2,089.12 hectares, representing 11.2% of the area. In 2010, vegetation cover was further reduced to 1,831 hectares, accounting for 10% of the total land area. This trend continued in 2020, with vegetation covering 1,812.87 hectares, still making up 10% of the area. The consistent reduction in vegetation covers over the years. Over the three decades, there was a consistent reduction in vegetation areas, accompanied by increasing conversions to cropland and settlements, highlighting pressures from agricultural expansion and urban development. The reason for this according to respondents is that, deforestation is a major issue as people cut down trees for fuel wood, construction materials, and to clear land for agriculture, significantly reducing the city vegetation cover. Additionally, there's a continuous need to expand agricultural land to feed the growing population, leading to the clearance of forests and other vegetative areas for farms. Poor land management practices further exacerbate this problem. Based on the insights provided by experts from the Bishoftu City Administration, it is evident that deforestation and agricultural expansion are key drivers of vegetation cover decrease in Bishoftu Besides this cutting down of trees for various purposes, coupled with the continuous need to expand agricultural land to support the growing population, results in the clearance of forests and other vegetative areas. Moreover, poor land management practices exacerbate the situation, further contributing to the decline in vegetation cover. In Ethiopia, several studies have documented the decline in vegetation cover driven by population pressure and agricultural expansion food requirements. Farmers clear forests and other vegetated areas to create more space for crops and livestock. The growing population increases the demand for food, leading to the conversion of forests, shrub lands, and other natural vegetated areas into agricultural lands. This process results in significant deforestation and degradation of natural habitats (41–43).

3.3. Settlement

The data regarding with settlements in 1990, occupied 1,121.67 hectares, comprising 6% of the total land area. The area covered by settlements increased significantly in 2000, expanding to 2,040.5 hectares or 11.1% of the land. This growth continued in 2010, with settlements covering 2,517.4 hectares, representing 14% of the total area. By 2020, settlements had further expanded to 4,202.2 hectares, making up 22.8% of the land. Settlement areas increased significantly over the three decades, with substantial conversions from cropland and vegetation, indicating urban sprawl and infrastructure development. According to the respondents, Rapid urbanization and population growth are major drivers because of this more individuals migrate from rural to urban regions in pursuit of better opportunities, and the demand for housing and infrastructure escalates, necessitating the expansion of settlements. And also they emphasized the role of economic development and investment in urban locales. Cities are evolving into commercial, industrial, and service hubs, they noted. This transformation generates a need for additional residential and commercial spaces, thereby contributing to the expansion of settlements Moreover, government policies and urban planning decisions also significantly shape settlement patterns, and also Initiatives aimed at enhancing access to essential services like water, electricity, and transportation often drive the development of new residential areas and the expansion of existing settlements they explained. The insights from city administration experts underscore the multifaceted nature of settlement cover increase in Bishoftu city, driven by urbanization, population growth, economic development, and government interventions aimed at improving infrastructure and services. Related with this result studies indicated that the reason the expansion of settlement in Ethiopia is driven by several factors. Rapid population growth and urbanization have increased the demand for housing and urban infrastructure as people migrate from rural to urban areas in search of better opportunities. Economic development and government policies, including resettlement programs, have facilitated the conversion of agricultural and forest lands into residential and commercial areas. Improved infrastructure, such as roads and public facilities, further supports this growth. These factors collectively contribute to the significant increase in settlement areas to meet the needs of a growing and urbanizing population (40,43,44).

3.4. Wetland

The Wetlands covered 740.97 hectares, or 4% of the study area, in 1990. By 2000, the extent of wetlands had reduced to 592.56 hectares, representing 3.2% of the area. This trend of decline continued in 2010, with wetlands covering 486.2 hectares, making up 3% of the land. In 2020, wetlands further decreased to 462 hectares, comprising only 2.6% of the total area. Wetlands showed relatively minor but consistent conversions to other land uses, indicating environmental pressures from agriculture, urbanization, and possibly climate changes, impacting their stability and extent. According to the respondents the reason for this alteration is obtained from city administration experts: Urbanization: 'As nearby urban areas expand, there is increased pressure on land, leading to encroachment into the wetland area for residential, commercial, and industrial purposes. This urban sprawl results in the direct loss of wetland. And also agricultural activities, such as irrigation and the conversion of wetland areas into farmland can significantly reduce the extent of the wetland. Therefor urban and agricultural expansion, infrastructure development, climate change, and LU changes are significant drivers of wetland loss. "Since the early 1900s, approximately half of the world's wetlands have disappeared. This loss represents a significant decline in these vital ecosystems over the past century. Wetlands, including marshes, swamps, and peat lands, play crucial roles in biodiversity conservation, water filtration, flood control, and carbon sequestration. The decline in wetlands is primarily attributed to human activities such as urbanization, agriculture, and infrastructure development, which often involve the draining and conversion of wetlands for other land uses(45).In the Ethiopian context studies showed that the wetland coverage decrease throughout time the researcher conducted in Bahirdar city showed that The development of social services, market centers, and infrastructure in close proximity to residential areas has also resulted in the loss of pasture space, cultivated land, wetlands, and other natural areas (3) .another research conducted in Ada'a Berga woreda showed that The study found that the absence of a wetland management scheme in the area was primarily due to a lack of belongingness, cooperation among neighboring administrative districts(woreda) and insufficient awareness, training, and community participation in wetland conservation efforts. Consequently, without intervention, the wetland faced threats such as the expansion of farmland, overgrazing, widespread development of residential areas, and excessive harvesting of grass(46) .

Conclusion

The comprehensive analysis of LULC changes in Bishoftu City from 1990 to 2020 reveals significant transformations driven by urbanization, agricultural expansion, and infrastructure development. While cropland remains the dominant land use category, it has experienced a notable decline over the past three decades. Conversely, settlement areas have expanded rapidly, indicating significant urbanization. Vegetation cover and wetlands have also experienced reductions due to human activities such as deforestation, agricultural practices, and urban encroachment. These findings underscore the urgent need for sustainable land use planning and conservation strategies to mitigate the negative impacts of these LULC changes and ensure the long-term environmental sustainability of the region.

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Conflicts of Interest

The authors declare no conflict of interest.

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