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Analysis of Trends in Land Utilization and Land Cover Dynamics in the Kwahu West Municipality, Ghana

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Abstract: The connection between people and the environment has been blamed for changes. Planning for sustainable development requires awareness of land use and land cover (LULC), its severity, causes, and implications. The purpose of this study was to generate maps that illustrate the land use and land cover within the Kwahu West Municipality and detect changes to identify and analyse overall patterns in LULC changes in the area. This research employed remote sensing techniques to assess land use and land cover alterations (LULC). This study used Landsat 7 Enhanced Thematic Mapper (ETM+) images from 2001, Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images from 2015, and Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images from 2023 to detect and quantify LULC changes that occurred over a 22-year study period. Arc GIS 10.8 and ERDAS Envision 13 were used to pre-process the data. According to the study, built-up land and bare land rose in their respective areas and years by 10.675 km^2 (or 2%), 18.421 km^2 (or 5%), and 29.096 km (or 7%), respectively, between 2001 and 2015 and 2015 and 2023. The overall change from 2001 to 2023 was correspondingly 29.096 km. The results depicted a drastic change in the study area's forest vegetation, which can be attributed to a sharp rise in population, urbanisation, and other infrastructure projects. These changes have been determined to cause biodiversity loss and water contamination. It is recommended that the Municipality's Lands Commission initiate a public education campaign about creating local planning schemes for lands, especially in undeveloped and underdeveloped areas.

Keyword: Land Utilization; Land Use Land Cover Change; Trend Detection; Geospatial; Kwahu West

1.0 Introduction

Currently, 3.9 billion people, or 54% of the global population, reside in urban areas, with projections indicating that by the year 2050, this figure is expected to increase to 6.3 billion, with approximately 90% of the growth taking place in cities in developing nations (DESA, UN, 2018; Mora et al., 2018; Lee et al., 2023). Alterations in the utilisation of land and the extraction of resources driven by human activities such as agriculture, mining, excessive livestock grazing, urban and industrial sprawl, population expansion, and growing economic interest in natural resources collectively exert substantial detrimental effects on the environment (Liping et al., 2018). Changes in land use and land cover (LULC) caused by human activity have altered the Earth's surface. Due to increased mining, urbanisation, deforestation, and agricultural activity, Ghana's LULC fluctuations have risen significantly (Forkuo et al., 2021; Kankam et al., 2022). Numerous studies have been conducted to examine and evaluate the pace of change in LULC in different regions of the country due to the severe nature of this trend. Among these are the influence of land cover variability indicators on land surface temperature in Greater Accra, Ghana, and spatiotemporal land cover analyses (Devendran & Banon,2022), Consequences of changes in spatial and temporal land use/cover on the provision of ecosystem services in the coastal regions of southwestern Ghana, West Africa (Kankam et al., 2022), The influence of alterations in land use and land cover on the socioeconomic aspects and means of living within the Atwima Nwabiagya District, located in the Ashanti region of Ghana (Forkuo et al., 2021) and examining the interplay of land-use systems and surface temperature in South-Eastern Ghana's class dynamics (Sarfo et al., 2023).

Following Koforidua as the capital of the Eastern Region in terms of population density, Kwahu West Municipality in the Eastern Region has had extraordinary expansion, growth, and development activities, including large building construction, agricultural operations, and some reported illicit mining. No effort has been undertaken to systematically analyse the transformations resulting from the substantial increase in land consumption and land use and cover modifications. Consequently, the objectives of this paper are:

1. To generate maps that illustrate the land use and land cover within the Kwahu West Municipality through time, using Landsat satellite imagery and a GIS-based approach,
2. To detect changes to identify and analyse overall patterns and magnitudes in LULC changes occurring in Kwahu West Municipality over 22 years.

To start and boost land production, replenish lost vegetation, improve environmental conditions, and satisfy the demands of the municipality's fast-expanding population. Again, developing sustainable development plans will promote Sustainable Development Goal 11, which calls for inclusive, secure, resilient, and sustainable cities and human settlements. The uniqueness of a piece of research rests in its capacity to reframe earlier findings, generate fresh insights or insightful information on a topic of interest, challenge preconceived notions, and explore an uncharted course. This research will provide stakeholders with excellent knowledge of improving the government's ability to design comprehensive local and national land management policies for safeguarding, organising, and keeping track of the numerous natural resources in the Kwahu West Municipality.

2.0 Literature Review

Since the dawn of time, humans have been manipulating the Earth's surface to meet their requirements and assure their continuous presence on the planet. Still, the environment is deteriorating due to the severe state of LULC alterations, which are caused mainly by the expanding population. The connection between people and the environment has been blamed for these changes. Planning for sustainable development requires awareness of LULC, its severity, causes, and implications (Gondwe et al., 2021). The subject of global change has gained attention from scientists, geographers, and international leaders and has become a hot topic. The LULC is crucial to the research and analysis of global change. The availability of existing data on changes in land use and land cover (LULC) and the rate at which these changes are occurring will assist future ecological management and inform decisions in environmental planning (Chowdhury et al., 2018; Mengist et al., 2022). Accurately detecting changes in land use and land cover (LULC) presents a significant challenge when monitoring ecosystems and resources at local, regional, and global scales.

To optimise resource management and utilisation, a more excellent knowledge of the links and interactions between people and environmental phenomena is necessary, according to Aslami et al. (2018). A significant amount of change is occurring throughout Africa and Ghana due to LULC alterations, which have emerged as the primary driver of ecosystem service change on a global scale (Musetsho et al., 2021). In recent decades, African grasslands, woodlands, bushlands, and other plant cover types have been converted into agricultural and habitation areas (Abebe et al., 2022). Africa experiences an annual loss of over 50,000 square kilometres of natural vegetation. Overthe past 25 years, 16% of the continent's natural forest cover has disappeared (from 1975 to 2000) (Abebe et al., 2022). Agricultural and habitation land coverings have replaced most plant cover (Musetsho et al., 2021).

Modern LULC has undergone a tremendous transformation, adversely affecting the environment and socioeconomic system. For better decision-making, accurate identification and change detection are therefore crucial. Geospatial technologies are widely employed as a decision-making tool in almost every industry, including land use planning and modelling. The application of geospatial technology to manage and monitor natural resources and the surveillance of land use and land cover (LULC) transformation have emerged as intriguing fields of research (Kayet & Pathak, 2015). Enhancing our comprehension of landscape dynamics is facilitated by employing multitemporal satellite data to detect changes in land use and land cover (LULC) within various geographic regions (Rawat & Kumar, 2015). Understanding the dynamics of human activity in space and time has been aided by such investigations. Quantifying LULC changes in spatial data sets has become a prominent tool for making geospatial decisions because of the advanced nature of Geographic Information Systems (GIS) and Remote Sensing (RS) techniques and high-resolution satellite images (Abebe et al., 2022). Recently, more research has focused on assessing the potential of satellite data for categorising land uses, monitoring land occupancy, and measuring and analysing land use changes (Liping et al., 2018)..

2.1 Land Use

The core definition of land use is the activity(ies) humans engage on actual land and its resources for various purposes in a specific area (Joint et al. Organisation, 1999). It may alternatively be defined as the collection of inputs and actions made by people on a specific plot of land (Shukla et al., 2019). According to Lambin, Geist, and Rindfus (2006), land use refers to how humans utilise land for various purposes to meet their needs and demands. It encompasses the various activities and practices that occur on a particular piece of land. Land cover, on the other hand, refers to the physical characteristics of the land, including vegetation, water bodies, built structures, and natural features like forests or wetlands.

On the other hand, Aspinall and Hill (2008) define "land use" as the land's social, economic, cultural, or political purpose. Ezeomedo and Igbokwe (2013) define "land use" precisely as the use that man has made of the land. This includes all activities conducted on land, including farming and the construction of residential, public, and business structures, all designed to serve the particular needs or objectives of the local population. Land use was also defined by Bik et al. (2015) as the actual usage of a space. According to Foley et al. (2005), overexploitation of indigenous species and loss, alteration, and fragmentation of the natural cover of the land have all contributed to a fall in biodiversity. However, they concede that, although this confronts us with a problem, specific land-use strategies are necessary for humankind. Two major categories of global change, systemic and cumulative, were identified (Turner, 1994). Systemic transformation influences the biochemical mechanisms essential for the proper functioning of the biosphere. Depending on the scale of this transformation, it can lead to widespread alterations, similar to how the combustion of fossil fuels elevates the concentration of carbon dioxide in the atmosphere. Throughout history, cumulative change has been the most common type of human-induced environmental alteration. Geographically constrained incremental changes can eventually become global in scope if they are performed frequently enough. Examples of cumulative change include changes to the terrain, farmland, and grasslands.

2.2 Land Cover

According to Briassoulis (2004), when people transform the land for their own gain, land cover changes (LUC) are related to the individual. For instance, alterations might be afforestation, building, intensive farming, bushfires, overgrazing, and forest removal (Briassoulis, 2004). Moorman, Mason, Hess, and Sinclair (2006) argue that land use change (LUC) can be viewed as a result of human activity transforming natural ecosystems into purpose-built landscapes comprising residential, commercial, institutional, and industrial zones, along with the necessary supporting infrastructure. This perspective suggests that the imperative drives LUC to accommodate the evolving needs of society and promote economic development while acknowledging the transformation of the environment that accompanies such progress. By including spontaneity and purposeful adjustments in the appropriation to suit human wants, Briassoulis (2006) expanded the prior description. Briassoulis (2006) and Moorman et al. (2006) assume changes in a collective setting, but Briassoulis (2004) restricts LUC to the individual level.

2.3 Effects of Land Use/Land Cover Change

The direct and indirect effects of human efforts to gather necessary resources have changed the LULC since prehistory (Ruddiman, 2003). Due to the significance of its impact on the planet and its inhabitants, LULC alterations have received much attention (Verburg et al., 2006). In summary, these alterations significantly impact the functioning of the Earth's physical, chemical, and biological components in the short and long term while influencing people's long-term perceptions of the world (Lambin et al., 2003). Changes in LULC can have both positive and negative spatial and temporal effects. Nevertheless, the scales are primarily tipped in favour of the detrimental impact on the ecosystem (Global et al., 2005). Long-term, these harmful changes lessen the ecosystem's capacity to continue producing the commodities and services that people depend on (Turner et al., 1990). According to Lambin et al. (2001), changes in LULC are significant sources of air, water, and soil pollution and biodiversity loss. Due to LULC change, biodiversity is frequently drastically diminished. Forest species are lost inside deforested regions instantly when land is converted from a central forest to a farm, settlement, or barren ground (Oteng-Yeboah, 1994). Changes in land cover that affect how sunlight is reflected off land surfaces (albedo) are a significant contributor to global climate change and global warming (Tuner et al., 1994).

3.0 Conceptual Framework

The relationship between the LULC type, LULC change, impacts, and controls of land cover change must be presented understandably without oversimplification of the issues or their interactions. This study has adopted and merged two frameworks, namely, the conceptual framework of LULC dynamics (Nyatuame et al., 2023; Suale et al., 2023). The frameworks (Fig. 1) were evaluated and modified. Based on the conceptual framework, the researchers further constructed headlines that conceptualise the study area's problems. A section described the LULC type, which includes waterbodies, settlements/bareland, forests, and grassland/farmland. LULC types such as waterbodies, forests, and grassland can be altered into LULC changes such as farms and settlements. According to Tariq (2023), LUC happens when people convert natural ecosystems into artificial landscapes, including residential, commercial, institutional, and industrial districts and auxiliary infrastructure.

An increase in the drivers of LULC, such as settlements, farming activities, urbanisation, and industrialization, leads to an impact on LU, such as loss of biodiversity, loss of forest vegetation, and land degradation. The effectiveness of the institutions, policies, and processes, which include the activities of the Central Government, Municipal Assembly, chieftaincy, land use planning, and public education, will lead to a sustainable environment as outlined in the Sustainable Development Goal (SDG Goal 9). Wang, Chen, Shao, Zhang, and Cao (2012) emphasise the risk posed by fast LUC and push for the prioritisation of land use regulation to safeguard the land in urban areas. The adapted conceptual framework was designed and modified to enable analysis of the LULC, drivers and their impacts on the LU, and conservation and control strategies that can help alleviate such problems.

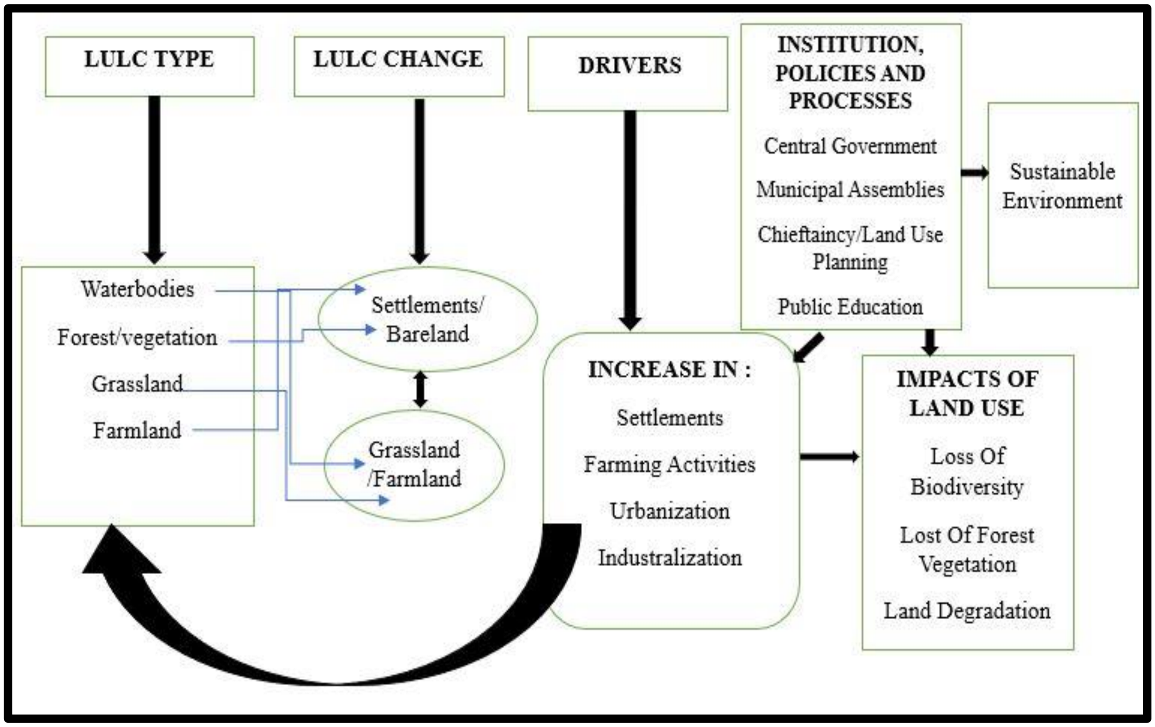

Figure 1: Sustainable Land Use Framework.
Source: Adopted from Nyatuame et al. (2023) and Suale et al. (2023)

4.0 Materials and Methodology

4.1 Site Selection

The Kwahu West Municipality was specifically chosen for this investigation because it is a preserved municipality undergoing urbanisation and needs land use and land cover maps with a lack of stringent urban planning and modelling. Maps of land usage and land cover are crucial for keeping track of and controlling human activity in such a western, semideciduous environment. The municipality's status as a preserved municipality implies a potentially rich and diverse ecological system. Monitoring land use changes is crucial to ensure sustainable development and prevent the degradation of ecologically sensitive areas. Again, Kwahu West is experiencing significant urbanisation, which often leads to changes in land use and land cover. The pressure for development might result in the conversion of agricultural or natural land to urban areas, affecting the overall landscape. Changes in land cover can affect water resources. For instance, urbanisation might increase impervious surfaces, impacting water runoff patterns and potentially leading to issues like flooding. Assessing land use changes in Kwahu West Municipality will help in effective water resource management. Also, the municipality was selected because there is an absence of land use and land cover maps, indicating a gap in the existing policy and planning framework. Generating these maps can provide valuable data for local authorities, urban planners, and policymakers to make informed decisions regarding sustainable development. Finally, Kwahu West Municipality was selected because generating land use and land cover maps can contribute to public awareness and involvement in sustainable development. It allows residents to understand the changes happening in their surroundings, fostering a sense of responsibility towards the environment.

4.2 Image Processing

ArcGIS 10.8 and Erdas Imagine 2013 were used to conduct all processing and post-classification tasks. Before being interpreted, each image was subjected to image pre-processing, which included radiometric adjustments. The data were all radiometrically adjusted and projected to UTM zone 30 N. Following the image pre-processing, maximum likelihood algorithms and supervised classification techniques were applied after the generation of classified signatures. Ten temporal reference points were utilised to cross-check the classification output from the supervised system before creating the LULC maps. See Figure 2.

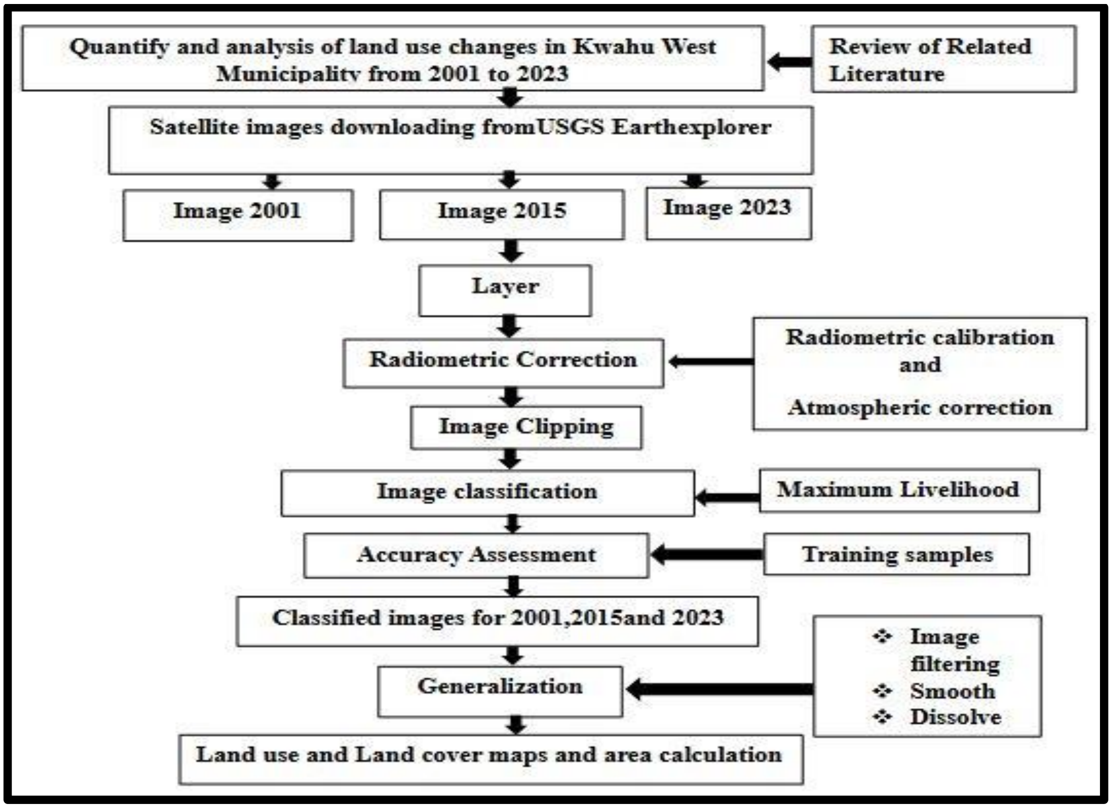

Figure 2: Methodological Flow of the LU/LC Change Detection in Kwahu West Municipality.
Source: Authors Construct, (2024)

4.3 Landsat Data

The categorization was done using Landsat satellite pictures from 2001, 2015, and 2023 obtained from the USGS Earth Explorer website (http://earthexplorer.usgs.gov). Landsat satellite images were chosen for this investigation due to their proven capacity to characterise land cover at a 30m spatial resolution, ease of access, cost-free nature, and extensive temporal coverage. See Table 1, illustrating data sources.

Table1. Comparison of the average content of component in sediment in Bernam catchment.

Year	Path/Row	Spatial Resolution	Satellite Sensor
2001	194/055	30m	L7 ETM+
2015	194/055	30m	L8 OLI/TIRS
2023	194/055	30m	L8 OLI/TIRS

Source: Landsat Metadata

4.3 Landsat Classification

Images were categorised using supervised classification algorithms and the connection of maximum likelihood. For accuracy, the classified images were adjusted against high-definition satellite photographs. In the end, four categories were established: waterbodies, settlements/bareland, forests, and grassland/farmland.

The process of categorising land use classes in the area began with a meeting with local elders and stakeholders to gather information about these classes. Additionally, we cross-referenced this information with existing literature and conducted fieldwork for verification. Utilising Anderson's Level I Classification Scheme (Anderson et al., 2001), we categorised the classes into four distinct groups, as shown in Table 2.

Table 2. Land Cover Change Classification Scheme

Land Cover Classes	Description
Waterbodies	Rivers, small ponds, streams, and reservoirs
Settlements/Bareland	Lands with sand or gravel and built-up areas
Forest	A large area of primarily trees
Grassland/Farmland	Lands with grass and woody plants smaller than trees and Fallow, crop, and vegetable lands

Source: Modified Anderson's Classification Scheme (Anderson, 2007)

4.4 Accuracy Assessment

Every LU dynamic identification depends on this to ensure the calibre of the categorised images. Using Google Earth Pro ground truth and data from Sentinel 10m satellite images for three chosen years, 25 training samples from each class were obtained to test accuracy. A ground control point for each year was confirmed using the Google Earth Pro engine's historical imaging capabilities. To see if the sample feature from the categorised picture was overlaid on the same land use class on the ground, each point was double-verified against the ground truth.

It was recognised as an accurate classification if it was superimposed on the same feature class in the Google Earth Pro images; if not, it was viewed as inaccurate. The Kappa coefficient (K) was calculated to assess the accuracy levels and demonstrate the agreement

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between categorised findings and actual circumstances. Accuracy is based on the images if the kappa coefficient is greater than or equal to 0.75. To represent each class as 25 points from those totals yearly, 525 Ground Control Points (GCPs) were amassed as ground truth sites.

The Kappa was determined using the equation below (Alqurashi & Kumar,2014).

$$K = \frac{N\sum_{i=1}^{k} xii - \sum_{i=1}^{k}(xi_{+} \times x_{+i})}{N^2 - -\sum_{i=1}^{k}(xi_{+} \times x_{+i})}$$

"In this context, 'k' represents the count of rows in the matrix. 'xii' signifies the number of observations in both row 'i' and column 'i.' 'xi+' and 'x+i' denote the total observations along row 'k' and column 'i,' respectively. 'N' stands for the total number of observations."

4.5 Change Detection

Change detection involves examining the disparities in pixel counts between two images captured at the commencement and conclusion of a designated study duration. This process assists in ascertaining the spatial extent of each land cover class over the study period. The change maps are juxtaposed with land use and land cover categorisation maps to gauge change size.

5.0 Results & Discussion

5.1 Land use Land Cover Changes

The following maps (Figures 3, 4, and 5) show Kwahu West Municipality and how the area is covered with several land characteristics, including waterbodies, settlements/bare land, forests, and grassland/farmland, according to the study of LULC changes using a supervised classification approach from 2001-2023.

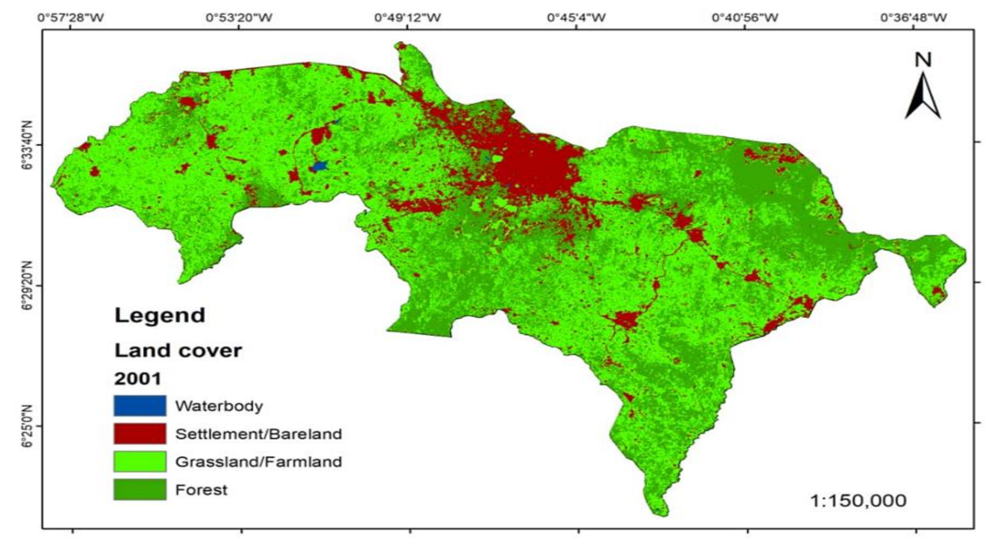

Figure 3: Land Cover Dynamism of Kwahu West Municipality in 2001.
Source: GIS Lab, Department of Geography Education, UEW

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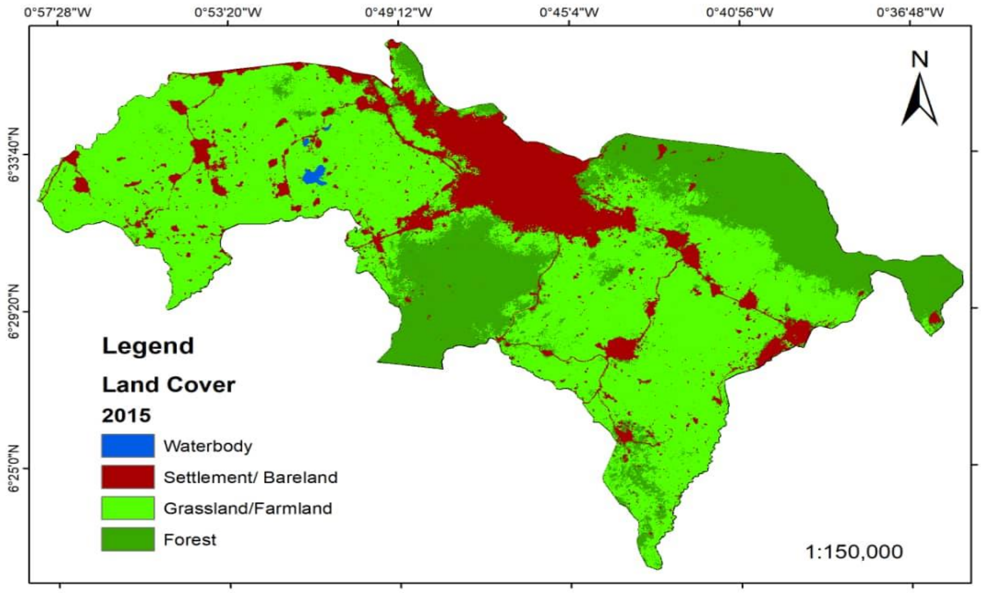

Figure 4: Land Cover Dynamism of Kwahu West Municipality in 2015.
Source: GIS Lab, Department of Geography Education, UEW

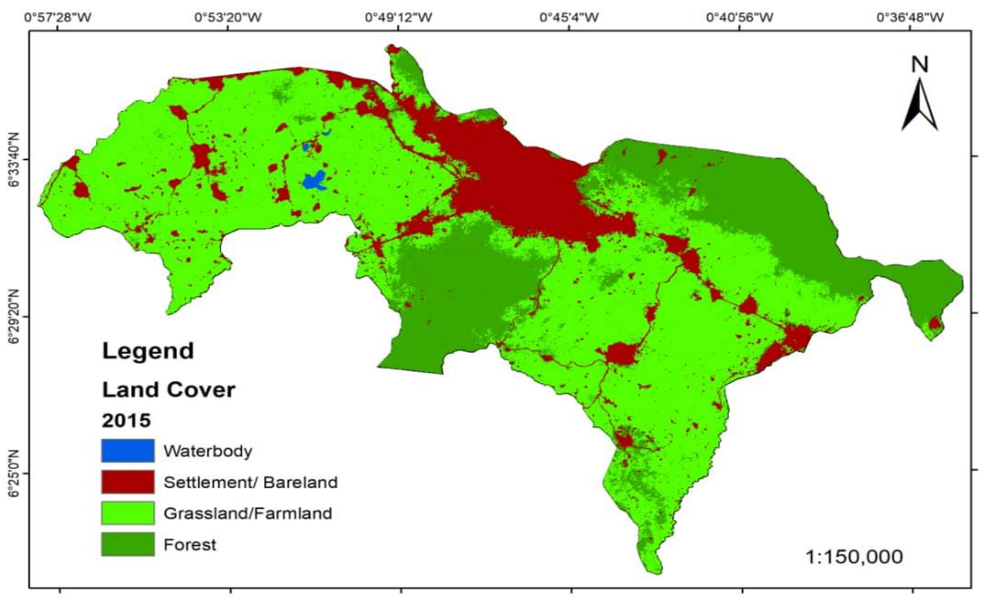

Figure 5: Land Cover Dynamism of Kwahu West Municipality in 2023.
Source: GIS Lab, Department of Geography Education, UEW

Table 3. Land Use and Cover Change Classes

Land Cover Classes	2023 Area (km^2)	2015 Area (km^2)	2001 Area (km^2)
Waterbody	3.451	1.881	1.502
Settlements/Bareland	80.300	61.879	51.204
Forest	95.189	100.854	150.201
Grassland/Farmland	225.060	237.386	199.092
Total	**402.000**	**402.000**	**402.000**

Source: Field Survey, (2023)

Table 3 presents LULC change classes for the three temporal periods selected for this study. It shows each parameter concerning its area coverage with their respective years. With this, waterbodies recorded 3.451 km^2, 1.881 km^2, and 1.502 km^2 for 2023, 2015, and 2001, respectively. Again, settlement/bare land recorded 80.300 km^2, 61.879 km^2, and 51.204 km^2 for 2023, 2015, and 2001, respectively. The forest covered 95.189 km^2 in 2023, 100.854 km^2 in 2015, and 150.201 km2 in 2001. Finally, grassland/farmland recorded 225.060 km^2 in 2023, 237.386 km^2 in 2015, and 199.092 km^2 in 2001.

The water bodies in the municipality under investigation in 2001, shown in Figure 5, totaled 1.502 km^2, or 1% of the total land area. Built-up or settled areas covered 51.204 km^2 (13% of the total land area). The primary indication of forest vegetation was examined, and the results showed that 37%, or 150.20 km^2, was covered by forests. Finally, 199.092 km^2, or 49% of the Kwahu West Municipality's total land area, was surrounded by forest vegetation.

As presented in Figure 4, the water bodies in 2015 totalled 1.881 km^2, or 1% of the total managed area. The grassland or farmland was the most prevalent unit, occupying 237.3867 km^2, or 59% of the land, followed by the forest with a 25% covered area, or 100.854 km^2. 61.879 km^2 were listed as settled, or 15%. The majority of settlements were found to be in the municipality's capital, Nkawkaw.

In 2023, the land use and cover categories within the Kwahu West Municipality, along with their respective surface areas and proportions. Approximately 23% of the total land area was covered by forests, making it the second-largest category. The most dominant class, grassland or farmland, represented around 56% of the municipality's total land area. Meanwhile, water bodies and settlements occupied 1% and 20% of the site, respectively.

The research area was divided into four distinct land use groups, including waterbodies, settlements/bareland, forest, and grassland/farm, according to the categorization findings from 2001, 2015, and 2023. The comparison of categorised images between 2001 and 2015 reveals that from 2001 to 2015, waterbodies increased by 2%, settlements/bareland decreased by 12%, forests decreased by 10%, and grassland/farmland increased by 10%. Again, between 2015 and 2023, waterbodies increased by 5%, settlements and bareland increased by 5%, forests decreased by 2%, and grassland and farmland increased by 3%. Again, from 2001 to 2023, water bodies increased by 7%. Settlements and land decreased by 14%. The forest decreased by 13%. grassland and farmland increased by 13%.

Table 4. Rate of Area Change Across Different Land Use and Land Cover (LULC) Categories.

Year	Area	Waterbodies	Settlements/Bareland	Forest	Grassland/Farmland
2001-2015	Acres	0.379	10.675	-49.347	38.294
	Percentage (%)	0	2	-12	10
2015-2023	Acres	1.57	18.421	-5.665	12.326
	Percentage (%)	0	5	-2	3
2001-2023	Acres	1.949	29.096	-55.012	25.968
	Percentage (%)	0	7	-14	13

Source: Field Survey, (2023)

5.2 Discussion

In the Kwahu West Municipality from 2001 to 2023, this study examined five LULC classes: forest, agriculture, grassland, bareland and settlement, and waterbodies. First, comparing categorised images from 2001 and 2015 shows that waterbodies increased by 2% between the temporal periods. Increasing water bodies means that natural water supplies may be better conserved. It could signify initiatives to protect or restore wetlands, rivers, and other bodies of water, which are essential for the biodiversity and health of ecosystems. Also, the results show that an increase in water bodies can help mitigate the effects of climate change by absorbing and storing carbon dioxide and providing cooling products in urban areas. Sustainable land use planning, water quality monitoring, and conservation efforts are crucial to sustaining the waterbodies in the municipality for future use. As outlined in the conceptual framework, the successful implementation of institutional policies results in a favourable outcome for environmental sustainability.

Once more, the settlement was the significant land use gainer in the research area. From 2001 to 2023, Table 4 of the overview of LULC trends in the Kwahu West Municipality shows that land use in the study area increased by +58.192 km^2. This results from urbanisation and the expansion of the research area's industrial, educational, and commercial service sectors. As elucidated in the conceptual framework, a rise in the number of divers in an area directly leads to the depletion of vegetation and biodiversity. Furthermore, there is a clear expectation of a shift in the Land Use and Land Cover (LULC) type. According to the study, urbanisation has been one of the key contributors to changes in LULC. Antwi et al. (2014) and Addo-Fordjour and Ankomah (2017), it is widely acknowledged that the primary driver of land use and land cover change (LULC) in Ghana, as well as in many other developing countries, is the combined effect of urbanisation and population growth. The development of bare, forest, and agricultural land backs this up. One of the traits that are thought to be connected to the expansion of the built-up area due to urbanisation is a loss of forestland. This is consistent with the findings of Munthali et al. (2009), who, while assessing the local perception of drivers of LULC change, established that the built-up area increased due to the development of agricultural regions, forest land, and bare land for commercial, academic, and business purposes.

The lack of implementation of the development plans in the urban centres, which led to the development of informal settlements, was another factor that contributed to the growth of built-up land. Jones (2017) and Carrilho & Trindade (2022) argue that to foster favourable conditions for the sustainable evolution of future informal settlements, planners must consider the same issues that are paramount in formal urban developments, such as balanced or planned land uses. Significant portions of the municipality that were not initially intended for residential use have been taken up by these unplanned urban sprawls. Economic possibilities may arise when settlement areas expand, particularly in the building, real estate, and allied industries. This may result in the development of jobs and a boost to regional economies. On the other hand, the growth of settlements in the study area frequently necessitates the creation of infrastructure, including public services, utilities, and roadways. While this may enhance the inhabitants' quality of life in the study area, it also puts financial pressure on local governments to make these investments. Ezeomedo et al. (2013) highlight that infrastructure is not a traditional asset but rather a liability for the city, as it incurs the ongoing obligation of maintenance and service. This underscores the financial pressure faced by local governments in managing and sustaining the infrastructure needed for growing settlements. The development of communities on natural or agricultural land may harm the environment. It may result in deforestation, a loss of habitat for species, a rise in pollutants, and modifications to the local microclimate. According to Suale et al. (2023), deforestation tends to occur through shifts in agriculture practices to meet market demands, and about 80% of global deforestation is a result of agricultural production, which is also the leading cause of habitat destruction. The growth of the built-up region may also be responsible. Population expansion and urbanisation dynamics are reflected in the rise of settlement land. For local governments and

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communities, it presents both possibilities and difficulties. Careful planning, sustainable development practices, and attention to social and environmental concerns are essential to ensuring that settlement expansion benefits residents and the broader community in the long term due to population growth (Atakorah et al., 2023). The threat of environmental unsustainability can be mitigated through the successful implementation of policies by the central government, municipal assemblies, and land use planning agencies, along with extensive public education, as outlined in the conceptual framework.

Even though the amount of farmland and grassland has changed, it appears to have grown. This could be brought on by increasing agriculture, modifications to land usage, or natural processes. As outlined in the conceptual framework, the growth of settlements and urbanisation, acting as catalysts, will directly impact the forest vegetation cover, ultimately resulting in the conversion of the land into either barren terrain or complete urban development. Farmland area has increased by 10%. Improving agricultural productivity and expanding the farming area may improve food security. However, the effectiveness and sustainability of agricultural operations are also crucial factors. It is essential to support sustainable farming practices that reduce their adverse effects on the environment and advance long-term food security. Farmland expansion, mainly through alterations in land use, may have a considerable impact on the environment. Forest conversion, for instance, can result in deforestation, leading to habitat loss, increased greenhouse gas emissions, and effects on biodiversity. Forest species are lost inside deforested areas immediately when land is converted from a primary forest to a farm (Oteng-Yeboah, 1994). Frequently linked to agricultural expansion, intensive farming methods can eventually reduce soil quality. This may result in lower agricultural yields and undermine the long-term viability of the municipality's agriculture. Therefore, it is necessary to consider the effects of expanding farming areas on the ecosystem. Government regulations, land-use planning, and conservation initiatives significantly shape the dynamics of agricultural growth. Unrestrained agricultural expansion can have detrimental effects, which can be lessened with sustainable land management methods and laws.

Also, over the previous 22 years, the forest vegetation has lost 110.024 km^2, making up the majority of the land use that has been lost. The results suggest urbanisation and increased human activity. This could imply a growing population, infrastructure development, or changes in land use. According to the works of Ayivor and Gordon (2012) and Adjei et al. (2019), the forest areas are attributed to the rise in land demand and land degradation activities such as deforestation, slash-and-burn farming, and illicit mining operations. The forest area has decreased from 2001 to 2023. This suggests deforestation or the conversion of forested land into other uses, which could impact biodiversity and the environment. This change may result from logging, agriculture expansion, or urban development. This population growth has led to increased urbanisation rates, clearing forested areas to construct various types of infrastructure, including residential, commercial, and industrial products, and establishing essential social amenities. This phenomenon has been noted in previous research, as highlighted by Tahir et al. (2013), Appiah et al. (2014, and Adu-Boahen et al. (2023). Forests are crucial in mitigating climate change by absorbing and storing carbon dioxide (CO2) from the atmosphere. When forests are cut down or degraded, the stored carbon is released into the atmosphere, contributing to greenhouse gas emissions and global warming. Another significant contributor to global climate change is the alteration of land cover, which affects how sunlight is reflected off land surfaces (albedo) (Tuner et al., 1994). Climate change and its effects, such as more frequent and severe weather occurrences, floods, and rising sea levels, are exacerbated by these land use and land cover change scenarios (Owusu et al., 2023). Once more, forests are essential for controlling local and regional water cycles. They support maintaining groundwater recharge, controlling streamflow, and preventing soil erosion. Reductions in woods may affect precipitation patterns, water quality, and the susceptibility to droughts and floods. Conservation activities, sustainable forest management techniques, and laws to protect and restore forests are crucial to addressing these detrimental effects. To stop deforestation, encourage reforestation, and prioritise the preservation of our planet's forests for the benefit of present and future generations, governments, organisations, and individuals must collaborate as far as the study area is concerned. This serves as proof within the conceptual framework that if institutions effectively address factors like urbanisation, industrialization, and settlement patterns, it will lead to positive outcomes in terms of environmental sustainability.

The average producer and user accuracies were 95%, 93%, and 97%, respectively, for different LULC classes in 2001, 2015, and 2023, according to data on user and producer accuracy and Kappa (K) values. The values for "settlement or built environment" that were observed to have the most remarkable and lowest producer and user accuracy were 95.5% (2023). For 2001, 2015, and 2023, Kappa accuracy ranged from 0.94%, 0.91%, and 0.96%. According to Li et al. (2012), the management of land use and land cover (LULC) in all classes may be significantly impacted by the classification algorithms' accuracy, making it a critical component of remote sensing analysis. The choice of an algorithm may be influenced by several variables, such as its efficiency, practicality, and ability to cross-compare with previous research. In many applications, such as urban sprawl (Shao et al., 2021), agricultural lands (Goga et al., 2019), LULC change, and water resources, remote sensing analysis has been actively used. However, the degree of precision gained determines the success and relevance of these applications to reality.

6.0 Conclusions

Based on Landsat satellite images and a GIS-based methodology, this research has effectively generated detailed maps illustrating the dynamic changes in land use and land cover (LULC) within the Kwahu West Municipality overthe past 22 years. The results of this study have shed a critical light on the patterns and scales of LULC changes that have taken place throughout time, providing insightful information on the municipality's changing terrain. The importance of this research goes beyond simple cartographic depiction; it has significant ramifications for the Kwahu West Municipality's sustainable development and environmental stewardship. The identification and analysis of these LULC changes provide a critical basis for well-informed decision-making aimed at resolving various issues, such as increasing land productivity, replenishing vegetation, and improving the ecosystem. Understanding these developments is also crucial for effectively addressing the municipality's residents' increasing needs in the face of a rapidly growing population.

The knowledge acquired from this research can influence the future creation of targeted policies, land management plans, and conservation initiatives that support the municipality's goals of sustainable development and environmental protection. This study has advanced our knowledge of the dynamic relationship between human activities and the natural landscape by utilising remote sensing and GIS technologies, paving the way for more efficient and sustainable resource management in Kwahu West Municipality and comparable regions. The effects of this research go beyond Kwahu West Municipality as we look to the future. The study of LULC changes is becoming increasingly crucial for tackling global environmental concerns as the world's population rises and urbanises. Applying the knowledge gained from this study will help us build more resilient and sustainable communities that balance the populace's demands with preserving our natural resources. By doing this, we can establish a more positive and harmonious link between human growth and the environment, ensuring a better and healthier future for everyone. The Municipality's Land Commission should start a public education campaign about creating local land use plans for the municipality's lands, especially in undeveloped areas. They can sell their land for more money, increasing its worth. Additionally, it has the benefit of avoiding encroachment on areas designated as conserved forests. To guarantee that land is not sold out and developed carelessly, the physical planning department at the municipal assembly should create a unified digital platform where all local designs for buildings may be recorded and monitored. This will help mitigate the adverse effects of the process and serve as an initial step to comprehend the dynamics and trends associated with changes in the municipality's land use and land cover (LULC). Consequently, municipal authorities and stakeholders should incorporate remote sensing and GIS applications into their management strategies. Pursuing knowledge makes consistent monitoring an invaluable tool for achieving this level of comprehension.

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