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Journal of Ecopolitics, Peace, and Sustainable Development (JEPSD)

Temporal Dynamics of Urban Green Space Transformation in Katsina, Northern Nigeria: From Pre-colonial to Post-colonial Eras

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Article Information

https://doi.org/10.69798/97874887

Published by: Koozakar LLC. Atlanta GA 30350, United States.

Edited by:
Prof. José Mvuezolo Bazonzi
Prof. Benjamin Mwadi Makengo

Abstract

The primary aim of this study was to assess the changes occurring in urban green spaces (UGSs) within the Katsina urban area. It employed an ex-post factor methods approach, which involved conducting interviews with key informants, organizing focus group discussions, making field observations and reviewing historical documents. Descriptive method was employed to analyze the collected data. The findings of this study revealed that UGSs have been preserved for hundreds of years and have served various purposes. However, UGSs have experienced series of changes due to various factors, including urban spatial expansion, population growth, changes in environmental and physical conditions, social and economic transformations, and political and administrative change. Essentially, this study suggests that traditional institutions in the pre-colonial period respected and preserved UGSs as sacred places, utilizing them for their socio-cultural and economic benefits. However, during the colonial era, UGSs were preserved and promoted to serve the interests of the colonialists. Following the independence of Nigeria in 1960 and the establishment of Katsina state in 1987, there was an unprecedented decrease in UGSs. It is therefore recommended that urban development policies in Katsina prioritize the restoration, protection, and sustainable management of urban green spaces through strengthened institutional frameworks, community participation, and integration of traditional conservation values into modern planning practices.

Keywords: Changing, Patterns, Urban, Greenspaces, Katsina, Urban-Area

INTRODUCTION

Urban Green Spaces (UGSs) are essential components of sustainable urban environments, significantly impacting the well-being and satisfaction of city residents (Yaro and Abdulrashid, 2012; Anwar *et al.*, 2016). Beyond their aesthetic contributions, UGSs are crucial in shaping the character and functionality of public spaces (Sati, 2015; Popoola *et al.*, 2016; Enssle and Kabisch, 2020; Semeraro *et al.*, 2021). Acknowledging their importance, national urban planning policies are increasingly incorporating the diverse needs of local stakeholders to enhance urban governance (Kimpouni *et al.*, 2020).

Despite their many benefits, UGSs are increasingly under threat, particularly in developing nations, where urbanization has led to significant depletion (Azare *et al.*, 2018; Haftu *et al.*, 2023). In Nigeria, studies have documented the gradual loss of UGSs amid rising urban pressures (Maiwada, 1995; Alabi, 2020). However, research on the historical changes and implications of UGSs in Katsina remains scarce, particularly regarding their evolution over centuries from pre-colonial to post-colonial periods.

This study aims to fill this gap by determining physical, socio-economic, and political factors influencing UGS changes in Katsina from the 13th to the 20th century and assessing the implications for urban livability and sustainability. Hence, it aims to elucidate historical patterns to inform effective strategies for the preservation and enhancement of urban green spaces within the region.

LITERATURE REVIEW

There are several definitions of UGS depending on the purpose, viewpoint, and background of studies using the definition. The European Commission (2013, p. 18) defines UGSs as:

"All public and private vegetated areas, regardless of their location, size and ownership, which are accessible to the public and contribute to the quality of life in urban areas, including parks, gardens, greenways, riverbanks and lakeshores, wooded areas, natural parks, and other open spaces."

According to Campbell (2001) UGSs are any vegetated land or structure, water, or geological feature found in the urban environment. Derkzen, (2017) sees public green spaces in urban areas as mainly areas covered by vegetation, designed for recreation, and with a positive effect on the urban environment, accessible to citizens, serves different needs, and improves the quality of life in cities or urban regions. Maimuna *et al.* (2022) considers UGS as large-scale outdoor environments with a lot of plants.

Despite the differences in definition, one important feature of UGSs is undeveloped land that is partially or entirely covered with wetlands, grass, trees, shrubs, or other vegetation. It often excludes indoor gardens and plants within homes, buildings, private and public areas, and workplaces. Table 1 summaries various definitions of UGSs based on analytical viewpoints.

This study adopts and modifies the definition of Urban Green Spaces (UGSs) as undeveloped land partially or entirely covered with vegetation, as proposed by Suligowski *et al.* (2021). UGSs encompass a wide variety of types, structures, and shapes, including public parks, green walls, and cemeteries (Roy *et al.*, 2012). Dunnett *et al.* (2002) established a comprehensive classification system for UGSs, categorizing them into four main types: amenity, functional, semi-natural, and linear green spaces, based on ownership, nature, and roles. Similarly, Mensah (2015) classified UGSs according to factors such as size, function, type of green areas, facilities, and ownership.

Bonsignore (2003) identified 26 distinct types of UGS in the United States, while Van Herzele and Wiedemann (2003) categorized them into six groups based on size. Baycan-Levent *et al.* (2004) proposed a division of UGSs into sixteen categories based on their values or functions. Azadi *et al.* (2011) identified eight major types of UGSs, including general UGS, brownfield redevelopment, greenways, and urban forests. In Yogyakarta, Indonesia, Indra (2008) classified UGSs into linear and non-linear spaces, which included town parks, sports fields, and leisure parks. Additionally, Mensah (2014a) and Fuwape and Onyekwelu (2011) recognized various UGSs in several African towns, such as semi-private spaces, public green areas, tree plantations, and nature reserves.

Table 1: Summary of Various Definitions of UGSs

Literature	Definitions
Campbell (2001).	Any vegetated land or structure, water or geological feature
Dunnett *et al.* (2002), and Forman (2008).	Terrain that is mostly made up of unsealed, permeable, "soft" surfaces.
Swanwick *et al.* (2003).	urban regions characterized by open land Including golf courses, parks, recreation spaces (excluding those linked with schools or other organizations), cemeteries, and enclosed agricultural and undeveloped territory inside urban areas
Swanwick *et al.* (2003).	An area considered natural that is rich in urban vegetation
Baycan-Levent *et al.* (2002).	Urban regions whose use does not require structures
Maas *et al.* (2006); Naibei (2018).	Public and private open spaces, primarily covered by vegetation
Byrne and Sipe (2010).	Natural reserve and wildlife protection zones including forests and agricultural green space. UGS are the 'green lung of cities that improve people's physical and mental health through walking, cycling, relaxing, socializing and children's play, as well as breathing spaces to escape the stresses of contemporary life.
Varna, and Tiesdell (2010); Agboola *et al.* (2016).	Uses ownership, usability and, public green accessibility to defined UGSs.
Fratini and Marone (2011).	All regions that are naturally or intentionally covered with vegetation.
Yusof (2012).	Region or land within a city that is covered with vegetation or water.
Rouquette (2013).	A wildlife corridor to enhance fauna mobility and reduce fragmentation and isolation.
Cheng *et al.* (2021).	All the green land/area covered by vegetation city-wide.
Semeraro *et al.* (2021).	Green infrastructure, which includes a network of all natural, semi-natural, and artificial ecological systems.
Lee *et al.* (2015).	Area with high-quality natural and artificial environmental features.
Palacky *et al.* (2015); Liu *et al.* (2022).	Outdoor areas that with natural features
Sandstrom (2002) and Bijker *et al.* (2017)	A network of all natural, semi-natural, and artificial ecological systems found at all spatial scales within, around and between urban areas.
Zakka (2017).	Public UGS in urban areas primarily covered by vegetation.
Suligowski *et al.* (2021).	All vegetated places including trees, shrubs, and grasses.
Maimuna *et al.* (2022).	Large-scale outdoor environments with a lot of plants.

Theoretical Framework

This section explores the interconnected theories and models that highlight the essential role of UGSs in urban development. As Mensah (2015) points out, existing models primarily address developed regions, yet they offer valuable insights for enhancing land use efficiency, environmental preservation, and sustainable urban planning, particularly within developing nations.

Land Use Change (LUC) models are essential for understanding how modifications in land use affect green spaces. They help identify vulnerable areas and evaluate conservation strategies. Key models include:

1. Markov Chain Models: These analyze historical data to predict urban green space (UGS) dynamics and assess different urban development scenarios (Strigul *et al.*, 2012).
2. Bid-Rent Model: This explains land price fluctuations relative to distance from city centers, highlighting how urbanization reduces UGSs (Alonso, 1964; Gao *et al.*, 2020; Abubakar, 2021).
3. Bit-Rebit Model: This aligns biodiversity conservation goals with local ecological conditions, ensuring that strategies effectively meet community needs (Abubakar, 2021).
4. Green Finger Model: This illustrates UGS patterns extending from urban centers, enhancing access to green spaces, exemplified

by Copenhagen's five-finger plan (Maruani and Amit-Cohen, 2007; Gotfried *et al.*, 2020).

5. Anugst Model: This sets standards for UGS accessibility based on population density, underscoring the importance of nearby natural spaces for urban residents (Nicholls, 2001; Pussella and Li, 2019). Overall, these models provide valuable insights for urban planning and conservation efforts.

Green Planning Models

Building upon the principles of the garden city model, Green Planning Models enhance UGS management. A notable example is the Garden City Model, developed by Clark (2003) to tackle challenges from the industrial revolution. This model integrates UGSs into urban planning, with successful applications seen in cities like Letchworth and Welwyn (Piacentini, 2021; Tunçer, 2021; Thorn *et al.*, 2021; Pastor *et al.*, 2023). By examining these theoretical frameworks, we gain a deeper understanding of the complex relationships between urban development and green spaces, paving the way for more sustainable and resilient cities. The interdependence of these models underscores the importance of integrating UGSs into broader urban planning efforts, enhancing both ecological and community well-being.

Green infrastructure plays a crucial role in conserving natural systems and promoting urban greening by prioritizing existing UGSs and implementing innovative solutions such as green roofs. These roofs provide significant environmental benefits, including improved air quality and reduced urban heat effects, which are essential in mitigating the impacts of climate change (Vijayaraghavan, 2016). However, their high costs and limited adoption hinder widespread implementation (MacIvor *et al.*, 2016). Greenbelts are another critical component of urban planning, designed to limit urban sprawl and protect recreational and agricultural areas. They serve as essential buffers against the encroachment of urban development (Monclús, 2018; Nguyen *et al.*, 2019). Despite their importance, greenbelts face challenges from rapid urbanization, which threatens their effectiveness in preserving open spaces and maintaining ecological balance (Le, 2017; de Souza Guida *et al.*, 2018; Holt *et al.*, 2019).

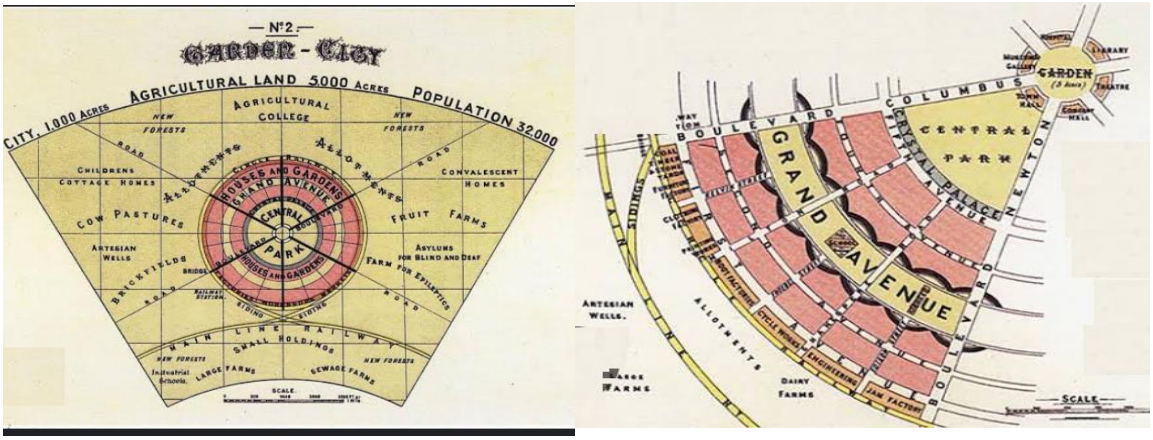

Figure 1: The Garden City Structure.
Source: Clark (2003)

In addition to greenbelts, greenways linear UGSs that run alongside roads and rivers enhance urban greenery and connectivity. These green corridors not only provide recreational opportunities but also support local wildlife and improve the overall urban environment (Keith *et al.*, 2018; Horte and Eisenman, 2020; Lynch, 2020). They play a vital role in creating a network of green spaces that fosters biodiversity and enhances the quality of life for urban residents (Mensah, 2015; Gotfried *et al.*, 2020). The concept of the "Green Heart" emphasizes the importance of UGSs in urban

centers for managing congestion and promoting greenery (Harrison and Harrison, 2007; Vejre *et al.*, 2010). This approach aligns with the principles of green urbanism, which advocate for the integration of UGSs and sustainability into urban development. It encompasses strategies for providing ecosystem services, utilizing sustainable materials, and promoting alternative transportation methods, all aimed at enhancing urban livability and combating climate change (Trudeau and Kaplan, 2016; Huang and Wey, 2019; Rayan *et al.*, 2022).

In summary, the interconnectedness of green infrastructure, greenbelts, green roofs, greenways, and the principles of green urbanism highlights the essential role of UGSs in fostering environmental sustainability and improving urban quality of life.

Review of Related Studies

This section examines the methods used to study the causes, impacts of UGSs change and various approaches to address the problem

Studies on UGSs Changes

Several studies have investigated changes in urban green spaces (UGSs), highlighting the significant impact of both natural and human-induced factors. Liu *et al.* (2014a) and Shahtahmassebi *et al.* (2021) identified that changes in UGSs are primarily driven by urbanization, development, government regulations, and urban planning practices. Liu *et al.* (2014b) employed geospatial techniques to analyze vegetation across 656 Chinese cities during a period of rapid urbanization, revealing negative effects of human activities on UGSs. Srinivasan (2014) pointed out that soil erosion, land degradation, depletion of soil fertility, and inadequate planning are critical factors contributing to changes in UGSs. In a detailed study, Li *et al.* (2018) utilized the Land Change Modeler, based on remote sensing data, to model spatiotemporal changes in UGSs over 30 years in Shenzhen, China. Their findings indicated a significant decrease in UGSs, although recent land use policies have helped to slow this decline. Similarly, Shen *et al.* (2017) analyzed landscape ecology in the Taipei Metropolitan area and found a 1.19% reduction in UGSs from 1995 to 2007, attributing this loss to insufficient spatial improvements that affected air quality and microclimate patterns.

In West Africa, Zayyana (2017) examined land use and land cover changes over 30 years across several countries, including Mauritania and Ghana, using statistical trend analysis of satellite-derived Normalized Difference Vegetation Index (NDVI) data. The study revealed significant land degradation, particularly in areas where agricultural land use was increasing, leading to a decline in closed forests and native vegetation species.

In Kumasi, Ghana, Gyasid (2020) utilized geospatial tools and interviews to explore the relationship between urban sprawl, flood occurrences, and UGS depletion. The study found that impermeable UGSs increased by 54% from 1986 to 2016, while permeable spaces decreased due to unregulated urban expansion. Mensah *et al.* (2020) further reported a loss of 19.59 km² of forest and 33.39 km² of agricultural land in Kumasi from 2000 to 2020.

In Nigeria, Onwuanyi and Ndinwa (2017) assessed changes in UGSs in Benin City, revealing significant political influences on the decline of open UGSs. Alabi (2020) analyzed land use changes in Lokoja from 1987 to 2007, finding that anthropogenic activities led to substantial vegetation loss. Maiwada (1995) documented the pressures on UGSs in Kano Metropolis, noting intense land pressure and declining open spaces. Abbas and Arigbede (2012) used remote sensing and GIS techniques to study gradual changes in UGSs at Ahmadu Bello University Main Campus, Zaria. Ladan (2022) examined vegetation cover in Katsina, identifying uncontrolled urbanization and misdirected government actions as significant factors affecting UGSs.

To this end, it is evident that UGSs, which have been preserved for centuries for various socio-cultural and economic purposes, are now facing unprecedented changes due to urban expansion, population growth, and socio-economic transformations. Traditional institutions historically respected and preserved these spaces, but post-colonial developments have led to significant declines, particularly in Nigeria since its independence in 1960.

MATERIALS AND METHODS

Study Area

Katsina is an ancient town in northern Nigeria, located about 40 km from the Niger Republic border.

It serves as the capital of Katsina State and covers approximately 23,938 km² (Google Earth, 2023; Mashi *et al.*, 2020). Positioned between Longitude 7° 34'30"E and 7° 39'0"E and Latitude 12° 54'0"N and 12° 58'30"N, the urban area includes parts of Katsina and Batagarawa local government areas (Zayyana, 2010; Hassan and Yakubu, 2010; Danbuzu *et al.*, 2014). The town, historically rich in UGSs, has faced environmental challenges such as rapid urbanization, desertification, and climate change, making it a significant area for studying UGS depletion.

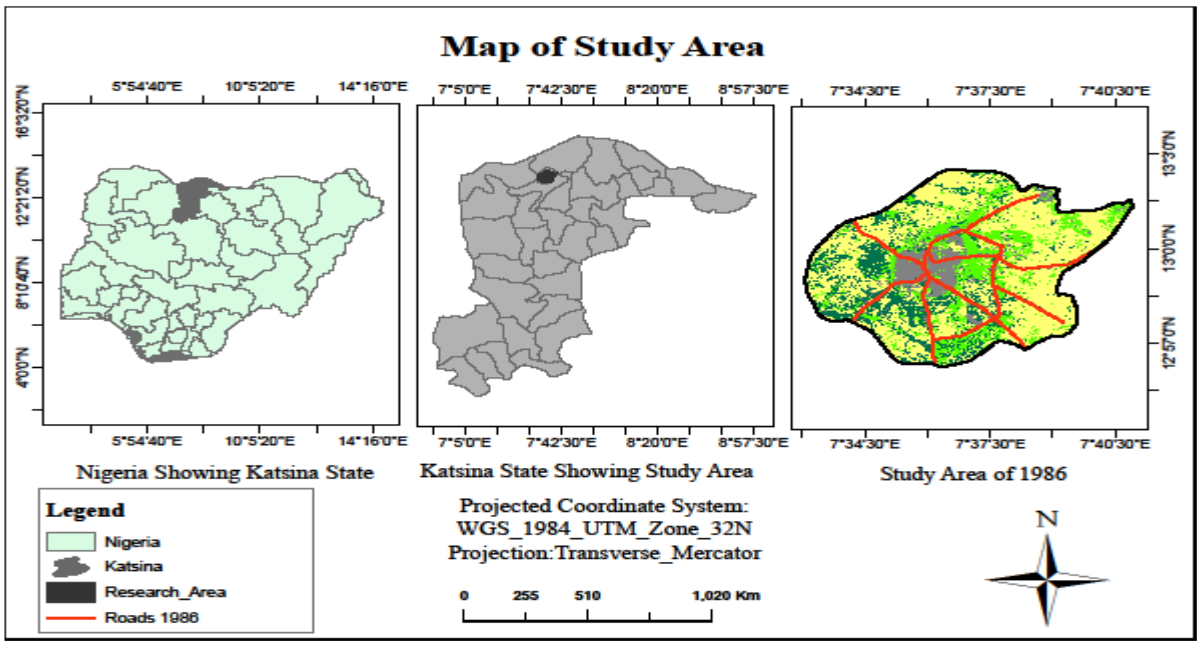

Figure 2: Katsina Town
Source: Supervised Image Classification (2022)

Climate

Katsina's climate is influenced by its position in the Sahel, acting as a transitional zone between the Sahara Desert and the Sudanian Savanna. The dry season lasts from November to March, with temperatures averaging 30-35°C (86-95°F) during the day, while the wet season, from April to October, is marked by higher humidity and rainfall peaking from July to September (NiMeT, 2022; Jande *et al.*, 2020). Long-term records indicate average annual rainfall around 750 mm, with temperatures exceeding 30°C (Mashi *et al.*, 2020; Godstime *et al.*, 2018).

Soil and Vegetation

The soil consists of crystalline rock and weathered materials crucial for agriculture (Abdulrasheed, 2012). The vegetation belongs to the Sudan savanna zone, characterized by drought-resistant species like Acacia and Euphorbia (Godstime, 2018).

Drainage

Katsina is drained by the seasonal Ginzo and Tille rivers, which are essential for stormwater management but face challenges due to urban development obstructing natural water flow (Mashi *et al.*, 2020).

Land Use

Urban expansion has led to the loss of green spaces, replaced by residential and commercial developments, including markets and banks (Yaro and Abdulrashid, 2017a; Danbuzu *et al.*, 2014; Dabo and Yunus, 2020).

Economic Activities

Katsina's economy is primarily agricultural, focused on crops like millet and livestock rearing. The town also serves as a commercial hub, facilitating trade and various artisanal crafts (Abubakar and Abdurrahman, 2018; Umar *et al.*, 2018).

Population and Settlement

The population mainly consists of the Hausa and Fulani ethnic groups, with a history of cultural fusion through trade and intermarriage (Zayyana, 2010; Umar *et al.*, 2018). Urban sprawl driven by population growth has increased demand for land, contributing to UGS depletion (Umar *et al.*, 2018).

Research Design and Approach

To analyze UGS changes in Katsina, the study employed a causal comparative method, gathering data from various sources, including archival records and interviews with local leaders and residents (Barau *et al.*, 2023). This mixed-method approach aimed to provide a comprehensive understanding of the changes affecting UGSs in the area.

To examine the extent of changes in UGSs in Katsina urban area, an ex-post facto research design known as the causal comparative method was adopted, based on the work of Santos and Santos (2015) and Puji *et al.* (2018). This method is suitable for investigating events that have already occurred and identifying factors contributing to them. The research involved gathering data from various sources, such as archival records, technical reports, historical documents, memoranda, and oral interviews with traditional leaders, ward (unguwa) and compound heads, Islamic scholars, historians, cultural experts, and senior citizens aged 50 years and above. Because their extensive experience of living in Katsina city has endowed them with greater knowledge about the town's overall system and the changes in land cover captured by satellite images in the study areas (Barau *et al*., 2023). Prior study recommended qualitative and quantitative methods, to use two or more observations of the same phenomenon in a given area (Simon, 2015).

This research strategy was adopted to obtain a chain of evidence from several sources to draw an informed conclusion, which will help to strengthen and increase the reliability of the study. According to Yin (2003) the utilization of various pieces of evidence or data to fully comprehend a phenomenon is one aspect of mixed method research that supports the triangulation of research findings from both primary (questionnaire, interviews, and personal observations) and secondary sources (books, journals, archival documents, annual reports; memorandum, documentary evidence, reports, and conference papers) that complemented one another. Therefore, the mixed method concept uses a variety of data, because of the types of questions study asks "how" UGSs in Katsina urban area changed, "why" they changed. The approach is widely known for providing a reliable method for gathering rich data from a range of sources and analyzing it to provide an in-depth analysis of a phenomenon or societal problem.

Data Sources and Types

This study employs a variety of data sources to explore changes in UGSs in Katsina, including Key Informant Interviews (KIIs), Focus Group Discussions (FGDs), Direct Observation, and Satellite Imagery.

Key Informant Interviews (KII)

KIIs involve structured or semi-structured interviews with individuals who have specialized knowledge relevant to the research topic. These interviews provide valuable insights and qualitative data essential for understanding UGS changes, their impacts, and potential restoration strategies (Mills *et al.*, 2010; Mensah, 2015). In this study, thirteen key informants were purposefully selected, including eight senior officials from public agencies responsible for UGS management and five traditional leaders knowledgeable in land administration. Interviews lasted 30-45 minutes and were recorded with permission to ensure accurate data capture. The interview guide focused on changes in UGSs, factors driving these changes, impacts on the environment and society, and possible restoration strategies (Abdulrasheed, 2012).

Focus Group Discussions

FGDs are organized group conversations facilitated by a moderator to explore specific topics (Manju and Gundumogula, 2020). This study conducted FGDs with five groups of six participants each, comprising community elders and public figures to gather diverse perspectives on UGS issues. The discussions mirrored the topics addressed in the KIIs, enhancing the richness of the qualitative data.

Field Observation Procedures

Direct Observation involves evaluating subjects in their natural settings without interference (Volkmar, 2021). The researcher observed UGSs in

Katsina for over three decades, analyzing historical videos and photographs to document changes, causes, and impacts. Observations were recorded through photographs and notes during fieldwork.

Historical Document Review

Satellite Imagery: Satellite remote sensing data was utilized to analyze the depletion of UGSs in Katsina. Landsat images from different periods (1986-2022) were acquired from the US Geological Survey Earth Explorer. Using Google Earth Pro and ArcGIS 10.5, the study employed spatial data analysis techniques, including supervised classification and area calculations, to classify land use and cover into four categories: reserved green area, built-up settlements, farmland, and vegetation. This methodology aligns with approaches taken by other researchers (Hassan, 2018; Mmaduabuchi *et al.*, 2020; Rikko *et al.*, 2022).

Historical Document Review

Triangulation in this study improves data analysis by integrating various methods. Questionnaires highlight trends, while FGDs and interviews provide additional context. The researcher validates findings by comparing themes from FGDs with responses from interviews and questionnaires. This combination of qualitative and quantitative methods enriches the data set and facilitates a more comprehensive analysis. Additionally, using multiple approaches reduces bias and addresses the shortcomings of any one method, resulting in more robust conclusions. Overall, these diverse data sources collectively enhance the study's understanding of UGS dynamics in Katsina, providing a comprehensive view of the environmental and socio-economic factors at play.

Data Analysis

This research on Katsina urban area utilized a sampling procedure that combined a projected population estimate of 453,580 and followed guidelines to achieve an adequate sample size of 783. A total of 800 questionnaires were distributed across five political wards, with 603 valid responses obtained (75.4% response rate). The study employed a multi-stage sampling design to ensure fair representation across varying ward sizes and neighborhoods. Accidental sampling was also used due to the lack of a sampling frame, allowing researchers to engage with residents directly in their neighborhoods, ensuring they met the age and residency criteria.

Ethical Considerations

Ground control points

The passage describes the process of collecting Ground Control Points (GCP) for assessing land use and land cover classification accuracy using high-resolution Google Maps. During a field survey, 16 GCPs were gathered via GPS from identifiable features like road junctions and buildings. These points were essential for reducing geometric distortion in satellite images by georeferencing them with ArcGIS Software, which also helped standardize the coordinate systems for spatiotemporal analysis (Hassan, 2018).

Depletion and regeneration models

This section describes two models used to analyze the area coverage of UGSs.

1. Depletion Model: This model calculates the percentage depletion of UGSs by comparing the area coverage in a designated year (X) to a subsequent year (Y). The formula is:

$$\text{Percentage Depletion} = \frac{(Y-X)}{Y} \text{ X } 100$$

2. Regeneration Model: This model assesses the percentage regeneration of UGSs by comparing the area coverage in the advanced year (Y) to the designated year (X). The formula is:

$$\text{Percentage Depletion} = \frac{(Y-X)}{Y} \text{ X } 100$$

Both models provide insights into the changes in UGS area coverage over time.

RESULTS AND DISCUSSION

The section discusses changes in UGSs in Katsina urban area from pre-colonial era to 2022. The chapter also presents the results of classifying satellite images to detect the depletion of UGSs from 1983 to 2024.

Spatial Patterns of UGS during Pre-colonial Era

This section addresses the significance of UGSs in the development of Katsina town, founded in the

13th century, highlighting features like the Tille and Ginzo valleys and lush vegetation (Abubakar, 1993). It outlines the evolution of UGS management across three historical periods: pre-colonial, colonial, and post-colonial.

During the pre-colonial era, Katsina was ruled by three dynasties (Durbawa, Korau, and Dallazawa), which maintained abundant UGSs (Usman, 1981; Abubakar, 1993; Danial, 1942). The Durbawa dynasty, in particular, integrated UGSs into their traditional religious practices, believing that spirits inhabited these natural areas. This reverence led to the protection of UGSs, as people avoided disturbing them out of respect for the spirits associated with rivers, forests, and other natural phenomena (Usman, 1981). Notable UGSs included the Bawada shrine and Tafkin-Butulu, which were significant for spiritual and communal activities. The Ambutai UGS served as a venue for wrestling competitions. The presence of sacred sites was crucial for community identity, further promoting the reservation and management of UGSs during the early Durbawa dynasty (Abubakar, 1993).

Muhammadu Korau (1444-1449)

Ascended to power by displacing the last Durbawa dynasty member and established a palace near the Bawada shrine to assert control over it (Usman, 1981). This political strategy linked his authority to the shrine, influencing the management of Urban Green Spaces (UGSs). In the 15th century, as Islam became the religion of the aristocracy marked by the first Muslim king from the Korau family there were significant shifts in UGS management, necessitating modifications to the existing spirit system and family totems (Usman, 1981).

The Conversion of UGSs for Islamic Practices

Led to adaptations, including the establishment of teaching and prayer areas, notably the Katsina central mosque and Kangiwa square (Munir, 2015). Prior to the Sokoto Islamic Jihad, Katsina was home to many scholars, which further transformed UGS purposes from religious shrines to educational spaces. During this period, various ethnic groups, including Fulani and traders from Mali, migrated to Katsina, reshaping the city into a center of commerce and Islamic learning. Notable figures like Sheik Almaghili facilitated the construction of significant Islamic structures, such as the Gobarau Minaret, which was surrounded by UGSs (Hull, 1968). Al-Maghili's successors continued the tradition of teaching Islamic texts in UGSs rather than formal school settings (Malumfashi, 2016; Dan-Asabe, 1997). Abubakar *et al.* (2018) noted that many UGSs served as Islamic schools during this era. Additionally, the Sabuwar Kasuwa market, initially a bush area, evolved into an Islamic school by the 17th century, reflecting the ongoing transformation of UGSs in Katsina.

Katsina Rampart and its enclosed UGSs

In the 15th century, large ramparts and trenches were constructed in Katsina to protect communities from external threats and internal conflicts (Hogen, 1930; Usman, 1981). The inner wall encircled the emir's palace and essential services, while the outer wall, Ganuwar-Amina, spanned 13-14 miles. During this period, much of Katsina's land remained unoccupied, supporting farming, markets, and open woodlands with notable vegetation, including Baobab and White Silk-cotton trees. As neighbourhoods developed in the 17th and 18th centuries, UGSs played a crucial role in political and commercial growth. Areas like Kwarin-Tama and the valleys of Tille and Ginzo became important for trade and iron mining (Munir, 2015). The establishment of trade routes led to the emergence of new neighborhoods, such as Yan-kyaure and Rafin-Dadi, which evolved from wetlands into significant trading crossroads (Palmer, 1924). The green areas also served various purposes: Sararin-Tsako was a camping site for travelers, while Saulawa and Kofar-Bai were royal farms that transitioned to residential areas. Sararin-Kuka and Mannar-Kadabo were originally green spaces used for markets and dyeing activities, respectively. Over time, many UGSs transformed due to urbanization and industrial activities, notably in Darma and Rafukka, which became centers for blacksmithing and irrigation farming, respectively, under successive emirs (Munir, 2015; Usman, 1981).

Cemeteries

There are three historic cemeteries that are UGSs and that date back to ancient Katsina. First, the old Dan-Marina cemetery is located within walled grounds between Rafin-Dadi Road and Kofar Kwaya Road. Second, the old Dan-Takum Cemetery, which borders the KTC compound (See Plate 1). Third, Rimin- Badawa cemetery is located just south of the expanded Government College

Plate 1: Old Dan-Takum Cemetery
Source: Fieldwork (2023)

enclosure These ancient cemeteries have been in continuous use before the arrival of colonial masters, because they are reusable (Munir, 2015).

Also, two cemeteries Dan-Marina and Dan-Takum have extensions close to one another. Apart from the two extensions of cemeteries, there are about twenty additional burial grounds situated outside the city Rampart, as follows: Behind Steel rolling mill; Around new GRA mosques; Behind Kofar-Sauri; Tudun Yan-lihida; kwado; Gidan-Dawa, Abattoir; Filin-Polo; Tudun-Matawalle; Garin-Abbas (close to new Yarkutungu market, Makera cemetery (near Barhin quarters) and Dutsin-Safe (Lawan, 2009).

Neighbourhoods Development

As neighbourhoods developed in the 17th and 18th centuries, UGSs played a crucial role in political and commercial growth. Areas like Kwarin-Tama and the valleys of Tille and Ginzo became important for trade and iron mining (Munir, 2015). The establishment of trade routes led to the emergence of new neighborhoods, such as Yan-kyaure and Rafin-Dadi, which evolved from wetlands into significant trading crossroads (Palmer, 1924).

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Plate 3: Abandoned Mannar Kadabo site
Source: Fieldwork, (2020)

Unguwar-Makera is a historic ward located between Kofar-Yandaka and Gafai, which has transitioned from a green landscape to one dominated by gold and blacksmithing activities. Darma (Lead) ward, originally a green space when the Katsina old town ramparts were built, became known for its blacksmithing industry during the Habe period. The area produced various metal items, such as knives and hoes, leading to its designation as Unguwar-Darma due to the lead work (Munir, 2015). Rafukka, meaning "numerous streams," was once fertile land for farming and irrigation since the Habe period, extending from the General Hospital to the Katsina rampart's northern

borders. Emir Muhammadu Bello first utilized the area's natural resources, followed by Emir Muhammad Dikko, who established a royal garden at Rafukka, enhancing its development (Usman, 1981).

Burrow pits, integral to the UGSs in ancient Katsina, were created from excavated mud for building materials. Some pits measured up to one hectare and 11 meters deep, functioning as reservoirs for sewage and stormwater, thus aiding drainage. Currently, about fifteen of these pits remain amid urban development, see plate 4 and 5.

Plate 4: Gangambu burrow pit *a*
Source: Fieldwork (2023)

Plate 5: Gangambu burrow pit *b*
Source: Fieldwork, (2023)

During the early 19th century, the Sokoto Jihadists took control of Katsina, leading to the establishment of the Dallazawa dynasty under Emir Ummarun Dallaje. Islamic laws protected UGSs, prohibiting grazing and designating green areas for religious and economic activities (Usman, 1981; Danial, 1942). Notable UGSs from this period include:

Sabuwar Kasuwa (New Market)
Initially a green area, it transformed into a market and later became a UGS with a mosque and learning center (Aliyu, 2007; Usman, 1981).
Eid Prayer Ground and Tudun-'Yan Lifidda: Developed during Ummarun Dallaje's reign, this area served as a watch point for horse soldiers and has since been developed but retained its prayer ground function.

UGSs at the Emir Palace
Surrounding the palace, these spaces served multiple civic purposes, similar to structures in other northern Nigerian emirates Daura (Urquhart, 1976).

UGSs around typical Hausa homes
Hausa homes typically featured three types of UGSs: public green areas, semi-private central areas, and private inner spaces. These areas were used for housing, agriculture, and animal rearing, connected by pedestrian pathways (Urquhart, 1976; (Abubakar, 2020). While few traditional homes still retain these UGSs, they historically supported various economic activities such as dying and blacksmithing (Munir, 2015). Overall, pre-colonization Katsina residents maintained a rich tradition of reserving UGSs for communal and agricultural uses (Urquhart, 1976). For Katsina town square, see Plate 4.

Spatial pattern of UGS during Colonial Era (1903-1960)
The colonial rule in Katsina started on March 28, 1903 when Sir Luggard entered the town. On November 9th, 1906, British removed Emir Malam Abubakar (the last of Dallazawa ruling families) and replaced him with Durbi Muhammad Dikko on January 25, 1907, thus, the beginning of the Sullubawa dynasty (Usman, 1981).

Plate 2: Town Square (Kangiwa) Near Emir's palace
Source: Max lock (1967)

The sixty years of British rule in Nigeria influenced urban development and growth of UGSs in Katsina (Moughtin, 1964).

British UGSS Planning Principle in Katsina

The indirect rule through the native chiefs was the fundamental tenet upon which Katsina Native Authority was founded. Sarkin Dawa is the chief, assigned to supervise forestry and green areas (Perham, 1965). Colonial masters established European reservation area (ERA) for their residences. The bungalow had a 100-yard enclosed area, positioned 30 yards from the public road. The bungalows were spaced 80 yards apart from each other, and each had a depth of 60 yards from the rear. The area also consisted of servant quarters and green areas (Urquhart, 1976). Second, residential segregation was made official and a 350-yard-wide buffer was created between European and native quarters to stop the spread of malaria to Europeans. Therefore, more UGSs were reserved for European homes because their compounds were surrounded by a mud wall, a strong fence, or living hedges. Grass and shade trees were planted in the fenced area. The dwellings were positioned so that the verandas front and back were always shaded (Munir, 2015).

By the year 1914 the buffer was expanded to 440 yards and designated as a building-free zone, (BFZ) which was converted into a green belt in 1953. Another government's strategy for UGSs enhancement, Katsina town was divided into wards (unguwa) in accordance with custom and each ward's leader was held accountable for the UGSs around them. High grass and bushes were maintained for at least 100 yards (Urquhart, 1976). Similarly, green area for horse racing, which was a long-standing custom in Katsina, that dates to the Habe era was provided along Jibia road by colonial rulers in 1918 under the reign of Emir Muhammadu Dikko (Munir, 2015).

Forest Reserves and Shelter Belts

These were developed to halt Sahara desert's encroachment and help to regulate the local climate as well as supply firewood and building material. The first forest reserve was created in 1922, and the NA forestry department was fully constituted, a sizable forest reserve was created in 1933, later a successful planted trees along key roads and in significant towns' markets (Hull, 1968). By the end of the year1936, 284 square miles of reserved land had been set aside, targeting 25% of the Emirate to be set aside for UGSs (Max lock, 1967). The Kabakawa, Nasarawa, and Barawa Forest Reserves, spanning 1028 hectares were created between 1948 and 1950 with the dual goals of serving as a future land reservoir for urban development and providing shelter for the Katsina town microclimate. Currently, more than 90% of the reserves have already been transformed into industrial and residential area.

Government Reservation Area (GRA)

This area transformed from the European Reservation Area (ERA). It was located outside of the city's rampart about a mile east of the city's

administrative buildings and junior staff housing. A tree belt covering an area of around 80 hectares was constructed surrounding the rampart in the 1950s and 1970s. The area was used for cattle grazing, which together with the BFZ that separate the old town from GRA shaped the old town. The GRA Green belt and Modoji Green Reserve covering 60 hectares of primarily neem trees were established in the 1950s and 1960s to improve the microclimate and curb desertification (Allen, 1972).

UGSs in public buildings and institutions during the colonial period: The Colonial masters reserved several UGSs even with the establishment of administrative offices, hospital and schools such as Katsina Elementary School, Government College Katsina, Katsina Teachers College and their staff quarters. These activities replaced the UGSs around Rafukka and Yammawa (Munir, 2015). The largest of these educational institutions was the Katsina College of Arts, Science, and Technology, which has a 600 hectare building zone and a further 1000 hectares of green area for agricultural development, mostly as teaching and experimental farms. The site begins on the west side of Dutsin-ma road about 4 kilometres south of the town. Additionally, ample UGSs have been set aside following the completion of construction (Max Lock, 1967).

Also, Munir (2015) indicated that Filin-Samji which was located within Kofar-Durbin on the northwest corner of the Katsina rampart was a thick forest in the past. The eastern part of the forest was later converted for sports and horse racing before it was transferred to its current location.

Spatial Pattern of UGS During Post-Colonial Era (1960 To 2022)

After independence, there were little changes to UGSs in Katsina until 1977 when the Federal Government obtained the land to establish the Katsina Steel Rolling Company, Sokoto Rima River Basin Authority, Federal (Shagari) low-cost Housing Estate, City Abattoir and Federal Mortgage Company Quarters. Except for the Federal Mortgage Housing Project, which is still uncompleted, the entire projects were executed before the creation of Katsina State in 1987. Large hectares of undeveloped leftover lands were set aside by the federal government as UGSs. Similarly, Max Lock's Group of Consultancy, (1967) developed a master plan for Katsina in 1978 and proposed several UGSs, including areas that have served as plantations during the colonial rule. However, most of the greens have vanished since Katsina state creation due to infrastructural projects such as the GRA extension, Katsina ring road and new the Katsina Government house.

Spatial pattern of UGSs in Katsina after state creation (1987-2022)

Katsina Town was designated as the government headquarters of Katsina state in September 1987, thereby atracting significant population and socioeconomic growth, which led to increases in the demand for spaces for residential, commercial, industrial, institutional, and office structures. From that time to date, very few UGSs remain, including the Maryam Babangida Children Park established in 1989, a trail plot of palm plantation located around Kofar-Durbi and a garden made under the Katsina State Afforestation Project Unit (KTAPU) as well as some other private gardens such as the Dan-Marna Zoo located along Shehu Yar'adu way, Lambun-Dan-Lawal located along Kofar-Sauri on the Kukar-Geza route, Lambun Wambai and Lambun Khadija both located along Daura Road.

Shortages of UGSs reservations and the numerous projects undertaken, which require spaces, resulted in the depletion of several UGSs. For instance, all three forest reserves (Kabukawa, Barawa, and Nasarawa) were converted into housing estates, roads, offices, and commercial structures. Similarly, most of the proposed UGSs were affected by development and urban sprawl. For instance, the Goriba designated green area was converted into Goriba Housing Estate. Furthermore, lambun-Sarkin-Fada (Kofar-Marusa) was converted into residential and commercial areas; lambun-Sarki (in the vicinity of Rafukka) into educational institution (Katsina Teachers College, Nasarawa, and Gidado Primary Schools, as well as residential and commercial areas. In addition, the green area, farms and gardens which started from the present General Hospital to Rafukka and extended to the border of the Katsina rampart to the north, borders of Kofar Sauri to the east, Nasarawa quarters to the south and Yamawa to the west, were converted to offices, classrooms, wards and quarter of Government College, Katsina, Teachers College, Scholarship Board, State Universal Basic Education Board and General Hospital. Other UGSs were converted to roads,

industrial, residential, educational and commercial structures. The GRA extension, Katsina outer ring road, and the new Katsina Government

UGSs change detection in Katsina urban area from 1986 to 2022

Table 1 presents the results of the depletion of UGSs in Katsina urban area for the period of 37years (1986-2022). It shows the classification for 1986, 1996, 2006, 2016 and 2022 satellite images, where the Green Reserve Areas, Farmland and other vegetal cover have been cleared for various purposes thus, shows significant increase in built up areas.

In 1986, the land area of the UGSs in Katsina consisted of different categories: a green reserve area spanning 1037.979515 km2, farmlands covering 5255.498232 km2, and vegetation encompassing 1846.246997 km2. There has been a significant increase (424.21%) in built up areas, which has resulted in the dominance of built-up spaces over green reserves, farmland, and vegetation areas.

In Figures 3 and 4, the changes that occurred in the first decade (1986-1996) are depicted. The green reserve area and vegetation experienced a decrease of 1098 km2 and 17.4 km2, representing a decline of 25.7% and 4.7% respectively. Conversely, the built-up areas and farmland witnessed an increase of 404 km2 and 711.8 km2, corresponding to a percentage growth of 0.47% and 24% respectively (as shown in Table 2). The land use that experienced the greatest depletion was vegetation, which was transformed into farmland. Additionally, during the initial ten-year period, urban expansion resulted in the conversion of a larger portion of the preserved green spaces

Figure 3 and 4 the changes that occurred from 1996-2006. The green reserve area, farmland, vegetation, and built-up areas experienced changes of +30.7, -1.74, -91.9, and +81.1 respectively. These changes corresponded to percentage changes of +14.6%, 33.03% - 3.56%, 2.31%, and 2% (as indicated in Table 4.2 and Figure 3). It is worth noting that these findings of UGS change align with the results obtained by Yaro and Abdulrashid (2017) and Idris *et al.* (2019). Notably, in 1990, the green reserve area increased by 30.7 km2, (14.6%) the vegetation experienced a growth of 81.9 km2, (2.31%) and the built-up areas expanded by 61.1 km2 (2%).

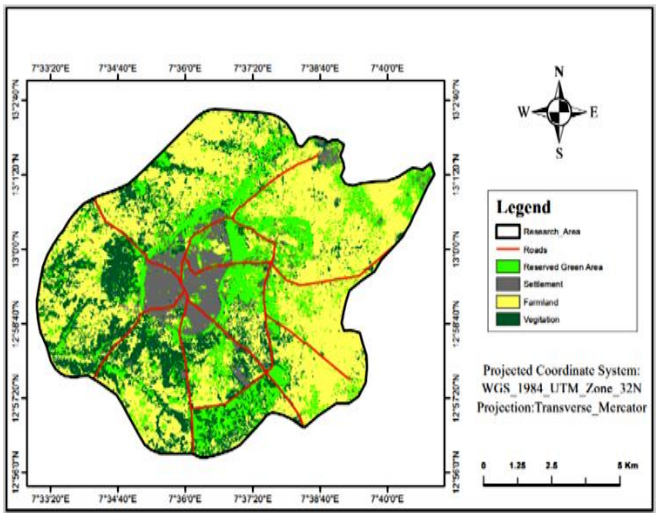

Figure 3: Land use/Land cover Distribution of Katsina Urban area (1986/01/08)
Source: Supervised Image Classification (2023)

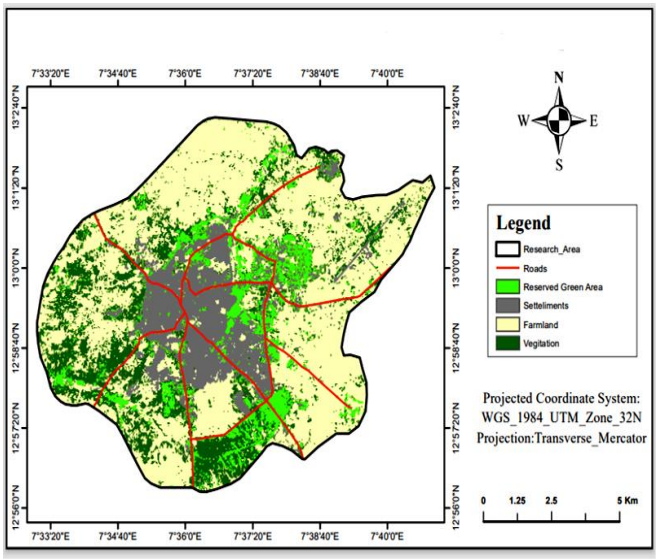

Figure 4: Land use/Land Cover Distribution of Katsina Urban area (1996/02/13)
Source: Supervised Image Classification (2023)

Ten years later (2006-2016), significant changes were observed in the green reserve area, farmland, vegetation, and built-up areas. The green reserve area experienced a decrease of 8.52 km2, (-6.63%) farmland decreased by 1.567 km2 (-16.7%), vegetation decreased by 3.59 km2 (-10.37%), and built-up areas increased by 2.787 km2 (+42.7%) (as indicated in Table 4.2 and Figure 4.2). Similarly, after seven years (2016-2022) further changes occurred. The green reserve area decreased by 2.05 km2 (-90.2%); farmland decreased by 4.5 km2 (-

7.07%); vegetation decreased by 4.96 km2 (-15.9%), and built-up areas increased by 1.10 km2 (+29.8%) (as shown in Table 4.2). Overall, when considering the total depletion from 1996 to 2022, the green reserve area decreased by 2125 km2 (-98%), farmland decreased by 1.743 km2 (-19.93%) vegetation decreased by 790 km2 (-27.2%), and the built-up areas increased by 4659 km2 (+68%) (as indicated in Table 4.2 and Figure 4.2). The urbanization of Katsina resulted in changes in its land use across three categories of land uses. These changes were influenced by the city's evolving status as a both a growing population center and an administrative hub.

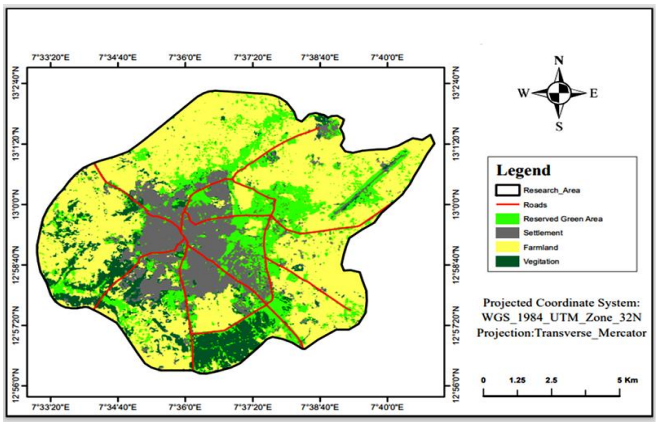

Figure 5: Land use/Land Cover Distribution, of Katsina Urban area (2006/11/26)
Source: Supervised Image classification (2023)

Specifically in 2016, a notable decline was observed in the green reserve area, with a decrease of 1842.6 km2 (-20.5%), farmland decreased by 2,357.2 km2 (-16.7%), and vegetation cover decreased by 849 km2 (-8.24%) (as depicted in Figure 6).

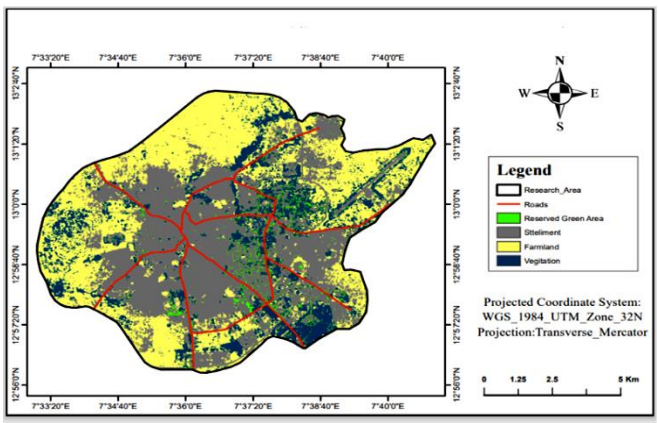

Figure 6: Land use/Land cover Distribution of Katsina Urban area (2016/05/07)
Source: Supervised Image Classification (2023)

In 2022, a significant decline was observed in the green reserve areas, farmland and vegetation covers. The green reserve areas decreased to 206 km2 (-90.2%), farmland decreased by 496 km2 (-15.9%) and vegetation cover decreased by 81.93 km2 (-12.6%) (as depicted in Figure 7). When considering the overall depletion from 1986 to 2022, the green reserve area experienced a decrease of 2125 km2 (2022%), farmland decreased by 1,743 km2 (14.2%), and vegetation decreased by 790 km2 (60.1%) (as indicated in the data).
Currently there is a significant decrease in the UGSs in Katsina urban area. Furthermore, when examining the overall depletion from 1986 to 2022, notable reductions (424.21%) were observed in the green reserve area, farmland, and vegetation.

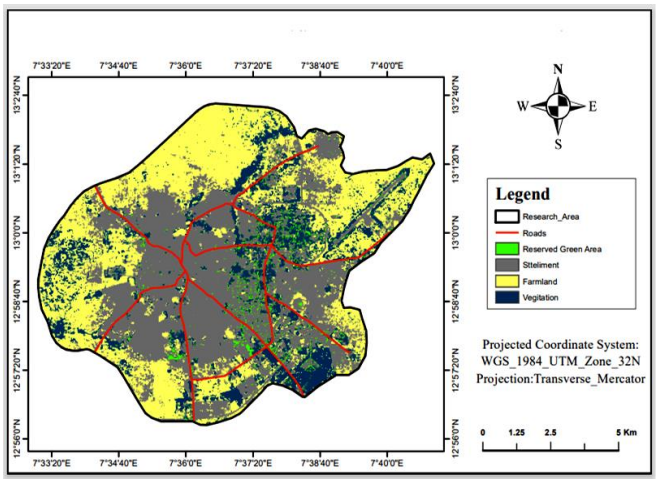

Figure 7: Land use/Land cover Distribution of Katsina Urban area (2022/01/11)
Source: Supervised Image Classification (2023)

Mmaduabuchi *et al.* (2020) used satellite imageries to study the changes in Katsina vegetation cover from 1999 to 2019 (Table 4.2). The authors found that the overlay results for the year 1999 indicated that 111.2 km2 of the total 126.41 km2 was made up of a built-up environment (29.3 %), vegetation (33.3 %) and bare surface (37.4 %). In the year 2009, the vegetation cover decreased to 122.35 km2 (-27.8%), built up areas increase to 202.86 km2 (46.2%) and the bare surface decreased to 114.66 km2 (-26 %) due to population growth, spatial structures and facilities were erected to meet the needs of the growing population. However, in 2019 there was decrease in vegetation covers to 81.93 km2 (12.6%) and a growth in built up areas with 479.27 km2 (73.5%) while the bare surface decrease to 91.16 km2 (13.9%) (Table 4.2), these changes in UGSs were a response to the growing

Table 2: Land Use/Land cover Dynamics for Katsina Urban Area 1999 – 2019

Land Use/Land	Extent (Km²) %			Change in Km²	
	1999	2009	2019	1999-2009	2009-2019
Built-up	111.2	202.86	479.27	+91.66 (82.4%)	+276.41 (136.25%)
Vegetation	126.41	122.35	81.93	-4.06 (3.21%)	-40.42 (33.03%)
Bare surface	142.10	114.66	91.16	-27.44 (19.31%)	-23.5 (20.49%)

Source: Mmaduabuchi *et al.* (2020)

population and urbanization, resulting in an increased need for urban land utilization. This table illustrates the changes in UGS in the Katsina Urban Area over a twenty-year period.

Summary of Changes in Katsina UGSS

The development of Katsina and its extensive UGSs illustrate key principles of urban ecology, highlighting the interdependence between human activities and ecological systems. Historically vital for agriculture and community gatherings, these UGSs have evolved through colonial governance and modern preservation efforts, emphasizing the need to integrate ecological considerations into urban planning. Additionally, the preservation of UGSs through structured governance practices, such as establishing buffer zones and green belts, showcases the importance of balancing urban development with ecological integrity while ensuring that management aligns with community values and cultural traditions.

The findings reveal significant changes in UGSs in Katsina State and their implications for urban ecology and environmental governance. Since 2000, the conversion of UGSs into residential and commercial developments has led to a decline in biodiversity, although the preservation of cemeteries and borrow pits offers potential conservation areas. This transformation has adversely affected essential ecosystem services such as air and water purification and temperature regulation, emphasizing the need for urban planning to incorporate the ecological functions of UGSs. Furthermore, the limited changes in UGSs prior to the establishment of Katsina State highlight a gap in environmental governance, indicating a necessity for policies that prioritize UGS preservation in urban development. As urban development increases, it becomes crucial to engage the community in decision-making processes to foster sustainable urban growth while maintaining ecological balance. Additionally, the ongoing changes demand strong regulatory frameworks to protect UGSs from encroachment, ensuring their integral role in urban planning.

Contrary to this trend, some studies (Douglas *et al.*, 2017; Ratcliffe *et al.*, 2021) indicate that new residential areas may also promote green environments through gardens and trees.

CONCLUSION

This current study emphasizes that natural spaces like pasture lands, river valleys, and traditional worship sites were essential for Katsina's establishment and growth. These areas existed prior to the urbanization of Katsina. However, significant changes have occurred since the creation of Katsina State, particularly during civilian rule, driven by various factors that warrant further research.

RECOMMENDATIONS

Based on the findings, the following solutions are proposed for the challenges in Katsina's urban area: Raise community awareness: Conduct awareness campaigns through various means such as public meetings, workshops, educational programs in schools, and media campaigns to educate the public about the importance of UGSs and their benefits. Engage media, traditional leaders, educational institutions, and religious organizations in campaigns to educate the public about the importance of UGSs. This can include public meetings, workshops, educational programs, and media outreach, highlighting the role of UGSs in food security, social interaction, cultural identity, and overall liveability.

Future studies should explore the factors driving changes in UGSs, their impacts on residents and the environment, and develop restorative and preservative measures for environmental sustainability.

REFERENCES

Abdulrasheed, L. (2012). Farmers' indigenous knowledge of land degradation and conservation measures in the Nigeria Sahel (PhD dissertation). The University of Abuja, Nigeria.

Abubakar, I. (2012). Households coping strategies with unsatisfactory urban services in a planned city of developing countries: A case study of Abuja, Nigeria (PhD dissertation). Florida State University, USA.

Abubakar, L. S. (1993). The great province. Lugga Press.

Abubakar, T. A., Abdullah, A. H., Ali, A. R., & Kabir, Z. M. (2018). Teachers' preference on application of audiovisuals in teaching Islamic religious studies in secondary schools: A case study of Katsina metropolis, Nigeria. International Journal of Academic Research in Business and Social Sciences, 8 (4), 754-771.

Abubakar, U. L., & Abdurrahman, A. (2018). An assessment of public health economy in Katsina State. Health Economics Outcome Research Open Access, 4 (160), 2.

Agboola, O. P., Rasidi, M. H., & Said, I. (2016). Residents' contribution towards improving physical quality of neighborhood open spaces in a multi-cultural community of Nigeria. Journal of Advanced Research in Social and Behavioural Sciences, 2 (1), 95-102.

Alabi, M. O. (2020). Sustainable urban form and challenges of open space utilization: Akure, Nigeria as a case study. International Journal of Urban Sustainable Development, 12 (3), 328-339.

Aliyu, A. G. (2007). Talim al-Radi fi-Asbab al-ikhtisas bi-Mawat al-Aradi (Written by Shaykh AbdulAllah ibn Fodiyo). The Centre for Islamic Studies, Usman Danfodiyo University Sokoto.

Allen, H. J. B. (1972). Aspects of urban administration in the Northern State of Nigeria. Savannah, 1 (1), 15-28.

Anwar, A. A., Al-Omran, A. M., Sallam, A. S., Al-Wabel, M. I., & Al-Shayaa, M. S. (2016). Vegetation cover change detection and assessment in arid environments using multi-temporal remote sensing images and ecosystem management approach. Solid Earth, 7 (2), 713-725.

Azadi, H., Ho, P., Hafni, E., Zarafshani, K., & Witlox, F. (2011). Multi-stakeholder involvement and urban green space performance. Journal of Environmental Planning and Management, 54 (6), 785-811.

Azare, I. M., Dantata, I. J., Musa, I. D., & Duala, T. (2018). Urban public spaces and associated environmental challenges in Nigeria: A review. International Journal of Innovative Research and Development, 7 (12).

Barau, A. S., Abubakar, I. R., Kafi, K. M., Olugbodi, K. H., & Abubakar, J. I. (2023). Dynamics of negotiated use of public open spaces between children and adults in an African city. Land Use Policy, 131, 106705.

Baycan-Levent, T., Van Leeuwen, E., Rodenburg, C., & Nijkamp, P. (2002). Development and management of green spaces in European cities: A comparative analysis. Research Memorandum, 2002 (25).

Bonsignore, R. (2003). The diversity of green spaces. Design Brief No. 2. Design Center for American Urban Landscape, University of Minnesota, Minneapolis, MN.

Campbell, K. (2001). Rethinking open space, open space provision and management: A way forward. Report presented by Scottish Executive Central Research Unit, Edinburgh.

Clark, B. (2003). Ebenezer Howard and the marriage of town and country: An introduction to Howard's Garden Cities of To-morrow (Selections). Organization and Environment, 16 (1), 87-97.

Dabo, M. Z., & Yunus, S. (2020). Road transport information system: A panacea for road transport facility management in Katsina local government, Katsina state, Nigeria. FUDMA Journal of Sciences, 4 (2), 466-477.

Dan-Asabe, A. U. (2014). Islam and history of learning in Katsina State from the Jihad to the colonial conquest: The case of the school Tsohuwar-Kasuwa, Katsina city. In A. T. Ismail & Abdullah (Eds.), Islam and the history of learning in Katsina.

Danbuzu, L. A. S., Tanko, A. I., Ibrahim, U. A., & Ahmed, M. (2014). Spatial distribution of solid waste collection points using GIS approach in urban Katsina, Katsina State, Nigeria. American Journal of Engineering Research, 3 (7), 107-116.

Danial, F. D. (1942). A history of Katsina memo: Senior Resident NAK/Library/1942.

Derkzen, M. L. (2017). Changing roles of UGS: Spatial and temporal dynamics (PhD thesis). Vrije Universiteit Amsterdam, The Netherlands.

Douglas, O., Lennon, M., & Scott, M. (2017). Green space benefits for health and well-being: A life-course approach for urban planning, design and management. Cities, 66, 53-62.

Dunnett, N., Swanwick, C., & Woolley, H. (2002). Improving urban parks, play areas and green spaces. London: Department for Transport, Local Government and the Regions.

Enssle, F., & Kabisch, N. (2020). The relationship between social cohesion and urban green space: An avenue for health promotion. International Journal of Environmental Research and Public Health, 16 (3), 452.

Forman, R. T. (2008). Urban regions: Ecology and planning beyond the city. University Press, Cambridge.

Fuwape, J. A., & Onyekwelu, J. C. (2011). Urban forest development in West Africa: Benefits and challenges.

Journal of Biodiversity and Ecological Sciences, 1 (1), 78-94.

Gao, J., Wu, Z., Chen, J., & Chen, W. (2020). Beyond the bid-rent: Two tales of land use transition in contemporary China. Growth and Change, 51 (3), 1336-1356.

Godstime, G. K. J. (2018). Assessment of environmental sensitivity to desertification in Katsina State, Nigeria. 6 (6), 545-555.

Google Earth Professional. (2023). Satellite image of Katsina Urban Area (30 meters spatial resolution). Retrieved from https://earthexplorer.usgs.gov.

Gyasid, K., Abass, K., Buor, D., Afriyie, K., Dumedah, G., Segbefi, A. Y., Guodaar, L., & Gyasi, R. M. (2020). Urban sprawl and green space depletion: Implications for flood incidence in Kumasi, Ghana. International Journal of Disaster Risk Reduction, 51, 101915.

Haftu, H., Weledegebriel, M. G., Gebre-Egziabher, A., Gebrehiwot, T., Zenebe, D., Berhe, B., & Gebretsadik, S. (2023). Experience sharing on continuity of healthcare services in internally displaced peoples: The case of Tigray war crisis. Risk Management and Healthcare Policy, 16, 2197-2208.

Hassan, A., & Yakubu, I. B. (2010). Socio-economic factors influencing household energy use in Katsina metropolis. Journal of Social Management Studies, 13 (1), 15-16.

Hassan, M. (2018). Geospatial analysis of the impacts of Jibia Dam on Jibia Town and its environs, Katsina State, Nigeria (MSc dissertation). The School of Postgraduate Studies, Ahmadu Bello University, Zaria.

Herzele, A., & Wiedemann, T. (2003). A monitoring tool for the provision of accessible and attractive urban green spaces. Landscape and Urban Planning, 63(2), 109-126.

Hogben, S. J. (1930). The Muhammadan Emirates of Nigeria. Oxford University Press.

Howard, E. (1902). Garden cities of tomorrow. London: Swan Sonnenschein & Co.

Hull, R. W. (1968). The development of administration in Katsina Emirate in Northern Nigeria, 1887-1944 (PhD thesis). Columbia University, U.S.A.

Idris, S., Mahmood, M. M., James, G. K., Olojo, O. O., Isah, A. A., & Mustapha, S. (2019). Land use/land change dynamics of Katsina State, Nigeria. International Journal of Advanced Research and Publications, 3 (8), 19-23.

Indra, H. H. (2008). Public open space utilisation: How people perceive it in Yogyakarta (Master's thesis). ITC, The Netherlands.

Jande, J. A., Godwin, N. N., & Mohammed, M. (2020). Prediction of land use change in Katsina-Ala through a geospatial approach. Journal of Agriculture and Sustainability, 13 (1), 20-23.

Kimpouni, V., Nzila, J. D. D., Watha-Ndoudy, N., Kokolo Bilongo, E. C., Yallo Mouhamed, S., Kampe, J. P., & Louembe, D. (2020). Sociocultural and ecological dynamics of green spaces in Brazzaville (Congo). International Journal of Ecology, 20 (20), 1-12.

Ladan, S. I. (2022). Assessment of environmental challenges posed by ponds in Katsina City, Northern Nigeria. In Proceedings of the Sustainable Research and Innovation Conference (pp. 86-92).

Lawan, I. A. (2009). Emergence and evolution of Unguwanni (wards) in Birnin Katsina, 1495-1949 (PhD thesis). Bayero University Kano, Nigeria.

Li, S., Yang, H., Lacayo, M., Liu, J., & Lei, G. (2019). Impacts of land-use and land-cover changes on water yield: A case study in Jing-Jin-Ji, China. Sustainability, 10 (4), 960.

Liu, W., Zhao, H., Sun, S., Xu, X., Huang, T., & Zhu, J. (2022a). Green space cooling effect and contribution to mitigate heat island effect of surrounding communities in Beijing metropolitan area. Frontiers in Public Health, 10, 870403.

Liu, Z., Ma, X., Hu, L., Liu, Y., Lu, S., Chen, H., & Tan, Z. (2022b). Nonlinear cooling effect of street green space morphology: Evidence from a gradient boosting decision tree and explainable machine learning approach. Land, 11 (12), 2220.

Maimuna, A. O., Ismaila, O. G., Ganiyu, O., Yusuf, A., & Chukwu, M. (2022). Urban green space accessibility in Ilorin City, Nigeria. International Journal of Real Estate Studies, 16 (1), 24-36.

Malumfashi, L. Y. (2016). The spread and development of Islamic civilization in northern Nigeria: Case study of Katsina State. International Journal of Business, Economics and Law, 9 (5), 173-179.

Manju, G., & Gundumogula, M. (2020). Importance of focus groups in qualitative research. International Journal of Humanities and Social Science, 8 (11), 299-302.

Mashi, S. A., Inkani, A. I., Oghenejeabor, O., & Asanarimam, A. S. (2020). Community perception, response, and adaptation strategies towards flooding risk in a traditional African city. Natural Hazards, 103, 1727-1759.

Max Lock Group of Consultancy. (1967). North Kaduna State sub-regional study survey and planning reports for Kaduna State government and Kaduna master plan.

Mensah, C. A. (2014a). UGS in Africa: Nature and challenges. Department of Cartography and Regional Planning, University of Cape Coast. Journal of Ecosystem, 4 (1), 212-214.

Mensah, P. A. (2014b). Destruction of urban green space: A problem beyond urbanization in Kumasi city. Journal of Environmental Protection, 1 (3), 1-9.

Mensah, A. C. (2015). Sustaining urban green spaces in Africa: A case study of Kumasi metropolis, Ghana (Doctoral dissertation). University of Birmingham.

Mensah, C., Atayi, J., Kabo-Bah, A. T., Vik, M., Acheampong, D., Kyere-Boateng, R., & Marek, M. V. (2020). Impact of urban land cover change on the garden city status and land surface temperature of Kumasi. Cogent Environmental Science, 6 (1), 1787738.

Mills, J. A., Durepos, G., & Wiebe, E. (2010). Encyclopedia of case study research (Vol. 1 and 2). Thousand Oaks: Sage Publications.

Mmaduabuchi, A. S., Bello, Y., & Yaro, A. (2020). Determination of factors responsible for the change in vegetal cover in Katsina Town. FUDMA Journal of Sciences, 4 (3), 636-644.

Moughtin, J. C. (1964). The traditional settlement of Hausa people. The Town Planning Review, 35 (1), 21-34.

Munir, M. D. (2015). The emergence of wards in Katsina. Department of African Language and Culture, Ahmadu Bello University Press Limited, Zaria, Kaduna State, Nigeria.

Nicholls, S. (2001). Measuring the accessibility and equity of public parks: A case study.

NiMeT. (2022). The Nigerian Meteorological Agency. Nnamdi Azikiwe International Airport Road, Abuja. Climate report on Katsina.

Palmer, H. R. (1924). The history of Katsina. Journal of African Society, XXVI.

Pastor, A. B., Canniffe, E., & Jiménez, C. J. R. (2023). Learning from Letchworth and Welwyn Garden City: Garden cities policies for the development of existing settlements in the contemporary world. Land Use Policy, 132, 106759.

Perham, M. F. (1965). Lord Lugard's dual mandate, with a new introduction in political memoranda. British Tropical Africa.

Piacentini, R. D., Vega, M., & Mujumdar, A. S. (2021). Beyond industrial revolution 4.0: How industrial revolution 5.0 is related to drying technology. Drying Technology, 39 (4), 437-438.

Popoola, O., Sati, Y., Chanle, U., Zanzan, J., & Zanzan, J. (2016). Perceptible attributes of urban green spaces in the architectural characterization of metropolitan areas in Jos, Nigeria. Department of Architecture, Ahmadu Bello University, Zaria. Research on Humanities and Social Sciences, 6 (4).

Puji Nor Akmar, A. A., Konijnendijk, C. C., Sreetheran, M., & Nilsson, K. (2018). Green space planning and management in Klang Valley, Peninsular Malaysia. Arboriculture and Urban Forestry, 37, 99-107.

Pussella, P. I., & Li, L. (2019). Identification and assessment of the driving forces for the use of urban green parks and their accessibility in Colombo, Sri Lanka, through analytical hierarchical processing. Geospatial Health, 14 (1).

Rikko, L. S., Pwajok, N. R., Namo, J. A., & Habila, S. K. (2022). Depletion of urban green spaces in Jos Metropolis, Nigeria Sahel. Journal of Geography, Environment and Development, 3 (2), 67-77.

Roy, S., Byrne, J., & Pickering, C. (2012). A systematic quantitative review of urban tree benefits, costs, and assessment methods across cities in different climatic zones. Urban Forestry and Urban Greening, 11 (4), 351-363.

Saad, A. (2024). Examining the changes in UGSs and a framework for restoration measures in Katsina urban area (PhD dissertation). Umaru Musa Yaradua University, Katsina, Nigeria.

Sandström, U. F. (2002). Green infrastructure planning in urban Sweden. Planning.

Santos, R. G., & Santos, R. B. (2015). Practice-based research: Ex post facto evaluation of evidence-based police practices implemented in residential burglary micro-time hot spots. Evaluation Review, 39 (5), 451-479.

Semeraro, T., Scarano, A., Buccolieri, R., Santino, A., & Aarrevaara, E. (2021). Planning of urban green spaces: An ecological perspective on human benefits. Land, 10 (2), 105.

Shahtahmassebi, A. R., Li, C., Fan, Y., Wu, Y., Gan, M., Wang, K., & Blackburn, G. A. (2021). Remote sensing of urban green spaces: A review. Urban Forestry and Urban Greening, 57, 126946.

Shen, Y., Sun, F., & Che, Y. (2017). Public green spaces and human well-being: Mapping the spatial inequity and mismatching status of public green spaces in the central city of Shanghai. Urban Forestry and Urban Greening, 27, 59-68.

Srinivasan, S. (2014). Extension of deforestation in Ethiopia: A review. Department of Economics, Madawalabu University, Bale Robe. EPRA International Journal of Economic and Business Review, 2 (2).

Swanwick, C., Dunnett, N., & Woolley, H. (2003). Nature, role, and value of green space in towns and cities: An overview. Built Environment (1978-), 94-106.

The European Commission. (2013). Green infrastructure implementation and spatial planning. Luxembourg: Publications Office of the European Union.

Thorn, J. P., Aleu, R. B., Wijesinghe, A., Mdongwe, M., Marchant, R. A., & Shackleton, S. (2021). Mainstreaming nature-based solutions for climate resilient infrastructure in peri-urban sub-Saharan Africa. Landscape and Urban Planning, 216, 104235.

Trudeau, D., & Kaplan, J. (2016). Is there diversity in the New Urbanism? Analyzing.

Tunçer, M. (2021). Can the British Garden City model be a solution for post-pandemic Ankara? Journal of Anglo-Turkish Relations, 2(2), 104-122.

Umar, N. K., Sulaiman, A. M., Giwa, S. M., & Sulaiman, A. Y. (2018). Spatio-temporal analysis of urban expansion in Katsina Local Government Area, Katsina State, Nigeria. Sokoto Journal of Social Sciences, 8(2), 95-106.

Urquhart, A. W. (1976). Planned urban landscapes of Northern Nigeria: A case study of Zaria. Ahmadu Bello University Press, Zaria, Nigeria.

Usman, Y. B. (1981). The transformation of Katsina 1400-1883: The emergence and overthrow of the Sarauta system and establishment of the emirate (PhD thesis). Ahmadu Bello University, Zaria, Nigeria.

Volkmar, F. R. (2021). Direct observation. In (Eds.), Encyclopedia of autism spectrum disorders. https://springer.com, New York, NY. pp. 980-981.

Yaro, A., Abdulrashid, L., Yahaya Sani, M. K. Usman, & Jerome Ayodel John. (2017a). Land use and land cover change assessment in Kaduna metropolis, northern Nigeria. International Journal of Applied Research and Studies, 4(8), 35-46.

Yaro, A., & Abdulrashid, L. (2012). Urban growth change analysis using remote sensing and GIS technologies: The case of Katsina Urban Area. Katsina Journal of Natural and Applied Sciences, 3(2), 1-14. Umar Musa Yaradua University, Katsina.

Yin, R. K. (2003). Case study research: Design and methods (3rd ed.). Thousand Oaks: Sage Publications.

Zayyana, Y. I. (2010). Some aspects of urban farming in urban Katsina, Katsina State. An unpublished M.Sc. thesis, Bayero University Kano.