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CONTENTS

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IMPACT OF URBAN SPRAWL ON LAND USE DYNAMICS IN SULEJA, NIGER STATE, NIGERIA

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Abstract

Most developing countries are now urbanising rapidly and prone to sprawl development. Urban sprawl in Niger state has adversely affected agricultural land due to rapid population increase and migration. This study analysed spatio-temporal changes in urban sprawl and land use change in the study area from 1990-2020. Landsat imagery data was acquired, and the data used was subjected to digital image processing to obtain the desired output using Erdas Imagine 9.2. The findings showed an increase of 5.2% (from 555.6 hectares in 1990 to 2552.0 hectares in 2005, from 2552.0 hectares in 2015 to 4346.7 hectares (9.7%), and from 4346.7 hectares in 2020 to 5712.8 hectares in 2020. Within 30 years (1990-2020), the built-up areas grew to 5712.8 hectares at 25.5%. The spread of the built-up regions is majorly residential development due to an increase in population that leads to a rise in demand for housing and forces people to the fringe where land is cheap. The study recommends that the government, through relevant agencies such as Ministry of Lands and Housing, enforce urban growth boundaries and the protection of vegetation especially forest by encouraging tree planting.

Keywords: Urban sprawl, Urbanisation, Population land use dynamics.

Introduction

Urban planners are interested in urban sprawl because of its connection to cities' environmental performance, a global phenomenon (Rubiera et al., 2020). "A pattern of land use in an urban area that demonstrates low levels of some combination of the eight district dimensions: density, continuity, concentration, clustering, centralisation, nuclearity, mixed-used, and proximity," according to the definition of urban sprawl (Richardson et al., 2004). Urban sprawl is commonly characterised as "an undesirable form of development, due to its economic, social, and environmental consequences," according to the Merriam-Webster dictionary. It is defined as "the spreading of urban developments on undeveloped territory surrounding a city" (Razin and Chang-Hee, 1998). The "structure and function of ecosystems in urban regions" are thus significantly impacted by urban sprawl (Tong et al., 2010). One of the main effects of changes brought on by population agglomeration in metropolitan areas is urban sprawl (Cobbinah and Darkwah 2016; Mosammam et al. 2017; Xu et al. 2019a). It has been defined by different academics to reflect the goals of their respective studies, even though it generally refers to the "unrestricted growth in many urban areas of housing, commercial development, and roads over large expanses of land, with little concern for urban planning" (Fouberg et al., 2012). Urban population increase is currently thought to be the primary cause of the extraordinary rate of urban sprawl, which is primarily being observed in cities in developing countries.

Urbanisation creates opportunities, but issues are also brought about for human life. In the opinion of some land use planners, urban sprawl improves the quality of life while fostering economic growth (Burchell et al., 2000). However, as human activity increases in cities, land use changes, which harms the affected urban areas (Deng et al., 2009). Almost all of Nigeria's main towns are seeing unplanned and unregulated growth, particularly around the edges of

the cities. When cities physically grow, the lines separating urban, suburban, and rural activity blur, creating the potential for valuable connections (Davis, 2012). The extensive informal and squatter colonies in the suburbs are the most obvious indication of this expansion. These peri-urban areas currently lack planning and have an ad hoc infrastructure deficit.

Studies on urban expansion have found remote sensing and Geographic Information Systems (GIS) to be valuable tools since they can track environmental changes. Remote sensing imagery, mainly medium- to high-resolution photos that successfully map metropolitan areas, provides high-quality data based on resolution (Isah, 2015). The Shannon Entropy Model (SEM) can be used to investigate any geographic phenomenon as a tool for determining spatial concentration or dispersion. SEM is a metric computation method that measures urban growth patterns by statistically accounting for spatial variance and temporal growth changes in an area (Yeh and Li, 1998). Additionally, it determines the extent of urban growth by evaluating the density of the land development (Lata et al., 2001). Among the available urban growth/sprawl measuring indices, Shannon entropy has proven to be the most dependable and durable statistic.

In order to analyse the spatiotemporal changes in urban sprawl and land use change in the research area from 1990 to 2020, remote sensing and GIS techniques are used. On the other hand, the issue of urbanisation in the Suleja suburb has typically been quick and chaotic, with deficits in infrastructure development within the Suleja urban edge. Rapid urban growth is frequently characterised by an ineffective governance system, subpar infrastructure development, bad land administration, and chaotic development in the sprawling districts of Suleja. In order to determine how much sprawl occurred in Suleja's peri-urban areas between 1990 and 2020, this study looks at the alterations that had already taken place.

Study Area

Suleja is a city in Niger State of Nigeria just north of Abuja, the capital of Suleja emirate, lying between latitude 9º 6'N and 9º 17'N and longitude 7º 6'E and 7º 12'E (Figure 1). It has an area of 136.33 Km^2 with an estimated population of approximately 699,814 in

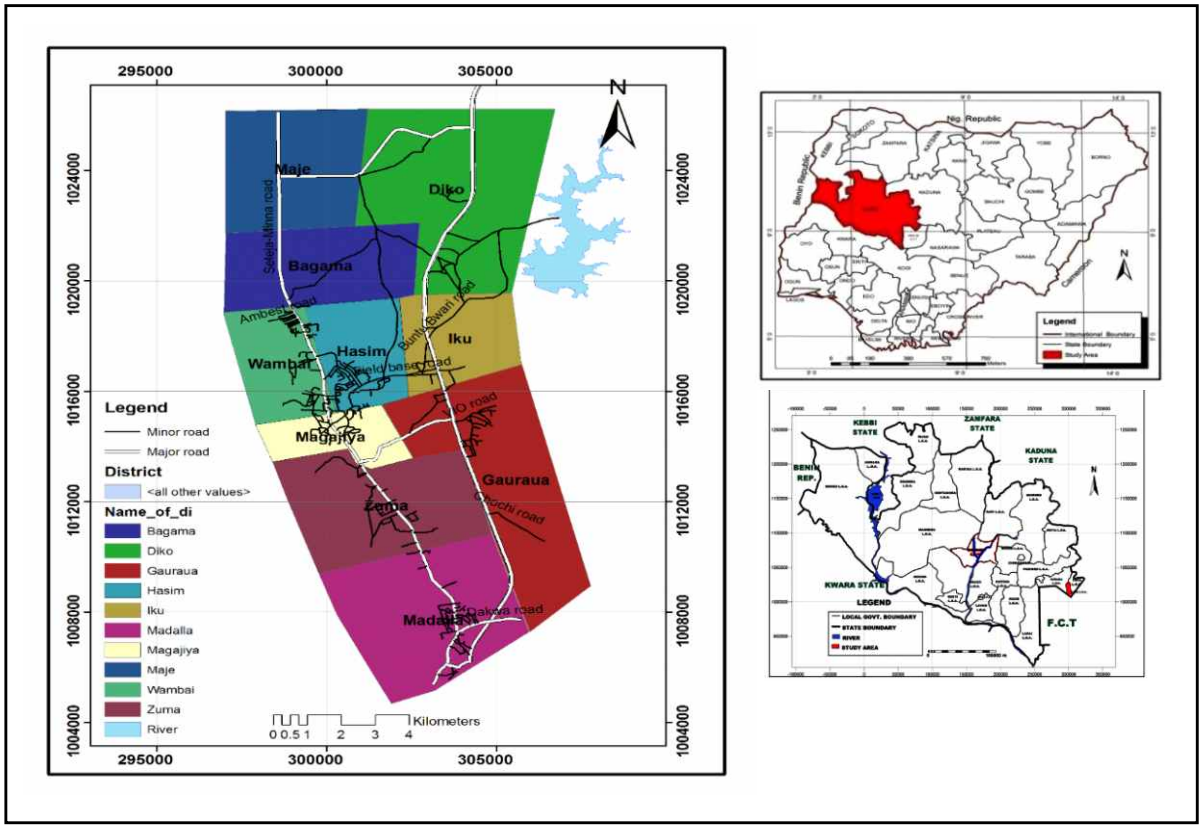

Figure 1: Study Area map
Source: Niger State Geographical Information System, 2021

2021 (NPC, 2021). Due to its proximity to Federal Capital City (Abuja), the population keeps increasing daily not only because of natural increase but due to migration to FCT and lack of accommodation and cost of living in the FCT. Suleja is within the tropical continent zone, with an average annual rainfall of 1600mm and a rainy season of over seven months. Temperatures are generally high in the summer months, which last from November to March. It falls within the Guinean forest-savanna zone of the West African sub-region. Patches of the rain forest, especially in the rugged terrain to the southeastern parts of the territory, are a landscape of gullies and rough terrain. These areas of Niger state form one of the few surviving vestiges of mature forest vegetation in the region.

Literature Review

Urban sprawl

Urban sprawl refers to the "unrestricted growth in many urban areas of housing, commercial development, and roads over large expanses of land, with little concern for urban planning" (Fouberg, Murphy, and DeBlij 2012) and has been defined by various scholars to reflect the purpose of their respective studies. Presently, growth in urban populations worldwide is considered the factor directly responsible for the unprecedented rate of urban sprawl being recorded majorly in cities within the global south. As the population of an urban centre increases, its need for infrastructures such as transportation, water, sewage and facilities such as housing, commerce, health, schools, and recreation increases, most often resulting in the phenomenon known as urban sprawl (Fenta *et al*. 2017; Sumari *et al*. 2017; Tanveer *et al*. 2019; Ujoh, Igbawua, and Ogidi Paul 2019).

Types of urban sprawl

There are different definitions of sprawl; however, they all share the same common thought: urban sprawl is the expansion of the metropolitan area outside its borders into the suburbs. In most cases, the development is a single purpose and car-dependent, agricultural and natural lands get lost, and patches and enclaves are created (Jat *et al*., 2008). Therefore, researchers have created classifications of the different types of sprawls. As stated, the kind of sprawl found in North America and Europe differs. In North America, development is not contiguous but spread out. In contrast, in Europe, the density is higher, but the form is more evenly and equally scattered across the region, thus leaving more open spaces (Batty *et al.*, 2003). Galster *et al*. (2001) have classified sprawl into the following five types: degree of compactness, dispersion or 'scatteration' (Figure 2).

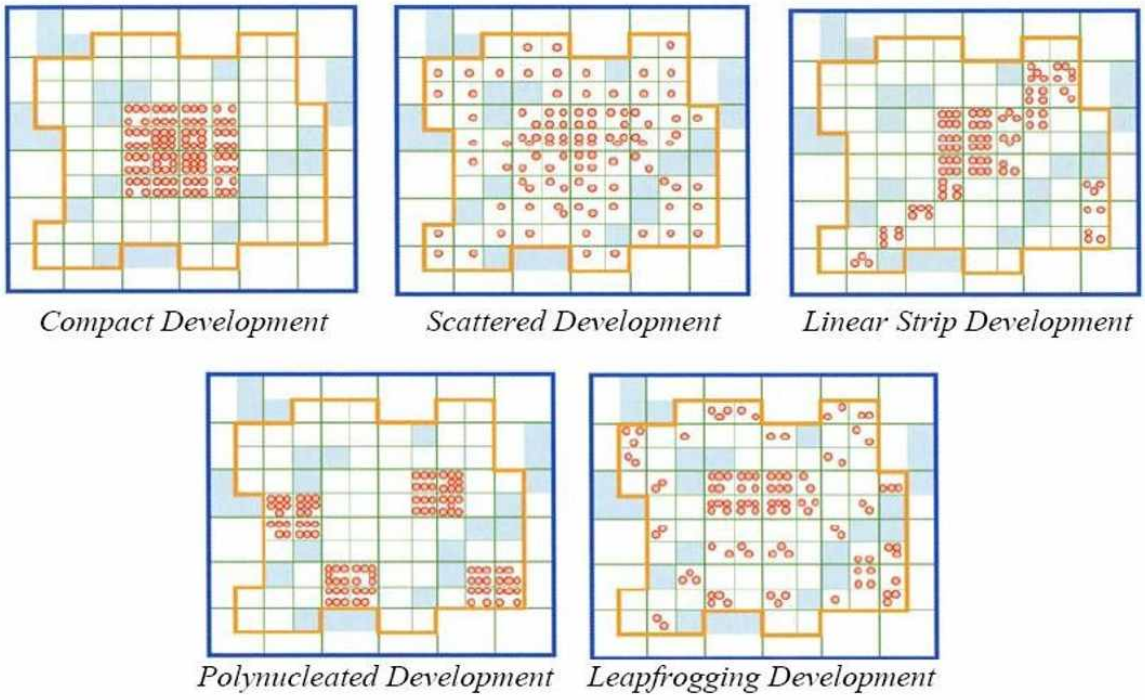

Figure 2: physical forms of sprawl
Batty *et al*., 2003

Compact, contiguous development: sprawl forms gradually around the urban area, not creating patches, and mainly has a high density. Strip or linear development: the urban expansion along infrastructural works or rivers; the evolution is continuous but scattered, leaving agricultural and natural land open. Poly-nucleated nodal development: several smaller towns are agglomerated, the sprawl is discontinuous, much lower density than the traditional settlement, and physically separated from the urban city of which it sprawled. Creating new 'larger' agglomeration of towns separately from each other (Batty *et al.*, 2003). The scattered sprawl development: uncoordinated discontinuous development away from the historical central core, creating open and vacant land between new built-up areas. Leapfrogging development: is the development that leapfrogs over existing barriers (Batty *et al.*, 2003; Besussi *et al.*, 2010).

Urban expansions in Nigeria

The pattern, trend and characteristics of urbanisation in Nigeria have been particularly significant (Aliyu & Amadu, 2017). Nigeria's towns and cities have grown phenomenally, with an urban growth rate consistently above 2% per annum (UNDESA, 2019). Consequently, there has been a rapid expansion of Nigerian cities' areas, often unplanned and uncontrolled (the Federal Republic of Nigeria, 2012). Several studies have shown that inadequate urban land use planning in Nigeria and intensity of use have exacerbated urban problems such as congestion, air pollution and heat stress (Federal Republic of Nigeria, 2012).

Urban expansion typically concentrates on the periphery of cities and towns. As land cover expands, the urban edge undergoes a constant process of redefinition (Bloch *et al.*, 2015). This frequently redefines urban boundaries and what is categorised as 'urban' and 'rural', creating complicated linkages between urban change, spatial expansion and urban governance. Bloch *et al*. (2015) comment that the emerging reality is that there is a mismatch between the extent of the land cover occupied by the built fabric and the existing administrative and institutional boundaries of Nigerian municipalities. Urban expansion is frequently not constrained within municipal limits but overlaps or spills over various Local Government Areas (LGAs) or even states. Due to their constitutional roles and powers, state governments thus emerge as key actors in the strategic spatial planning processes required to address the dynamics of current Nigerian urbanisation and urban expansion (Bloch *et al.*, 2015).

In Nigeria, a settlement is generally classified as urban if it comprises 20,000 people or more, a relatively high minimum population threshold compared to many other countries (Ofem, 2012). Nigeria's urban population has increased rapidly over the past five decades. It is projected to continue to grow in the foreseeable future, although how fast it is a matter of some dispute. UNDESA (2019) projections suggest that Nigeria's urban population will likely double within 30 years. The growth of Nigeria's urban population in both absolute and relative terms has also been accompanied by the expansion of existing built-up areas and the emergence of new and identifiably 'urban' settlements (Bloch *et al.*, 2015). Identifying urban centres in Nigeria is based on population and legal or administrative criteria. As noted above, Nigeria adopts a threshold population of 20,000 people as a criterion for defining an urban centre. In addition, all states and local government area headquarters have historically, legally or administratively regarded as urban 'centres (Federal Republic of Nigeria, 2012). At the national scale, the most extensive urban spatial expansion has been concentrated around four urban fields (Bloch *et al.,* 2015):

Material and Methods

This empirical research intends to analyse spatio-temporal changes in urban sprawl and land-use change in the study area from 1990-2020. The research uses both qualitative and quantitative approaches for data collection. Landsat imagery was acquired in 1990, 2005 and 2015. The imagery was subjected to digital image processing, which involves land use classification, calculation of the area in hectares of the resulting land use/land cover types for each study year and subsequently comparing the results and accuracy assessment. The three methods above were used to identify land use types change. Comparing land use/cover statistics assisted in identifying the magnitude of sprawl development between 1990 – 2020. The results were presented in maps, statistical tables and charts for clear illustrations.

Results

Suleja is an urban area experiencing rapid urbanisation and tremendous economic growth over the last three decades. The growing urbanisation in the city has created pressure for changes in the Land-use pattern. Infrastructural development, such as road networks, housing estates, and commercial development, has further enhanced land-use change in the area.

Urban sprawl and land-use change in Suleja from 1990-2005

The statistics of land use/ land cover distribution for 1990-2005, as derived from the image classifications and statistics of analysis, were presented in Figure 3.

The statistics of land use analysis revealed that in 1990 the predominant land use category was vegetation which accounted for 17418.0 hectares (47.1%) of the study area. Built-up land occupied only 555.7 hectares (2.7%), while bare ground occupied 7865.1 hectares (38.8%) and Open spaces occupied 2292.8 hectares (11.3%). This shows that at this period, the inhabitants of the study area were very few, and their occupation then was farming, hunting and other primary activities.

The 2005 statistics revealed that the built-up areas grew from 555.7 hectares (2.7%) in 1990 to 2552.1 hectares (7.5%) in 2005. Figure 4 shows the land use classification for 2005.

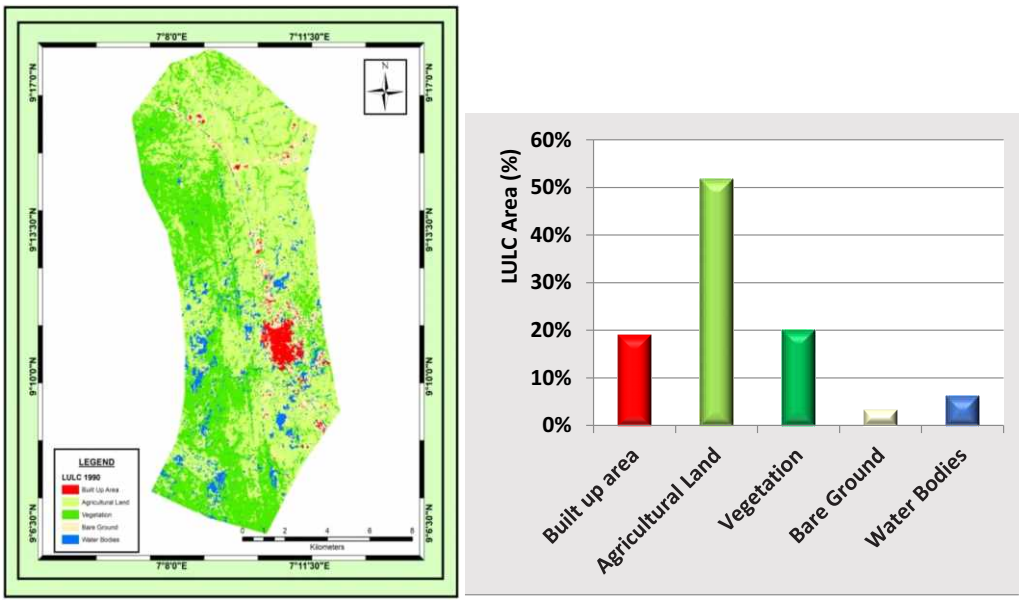

Figure 3: Land-use Land cover Map of Suleja in 1990

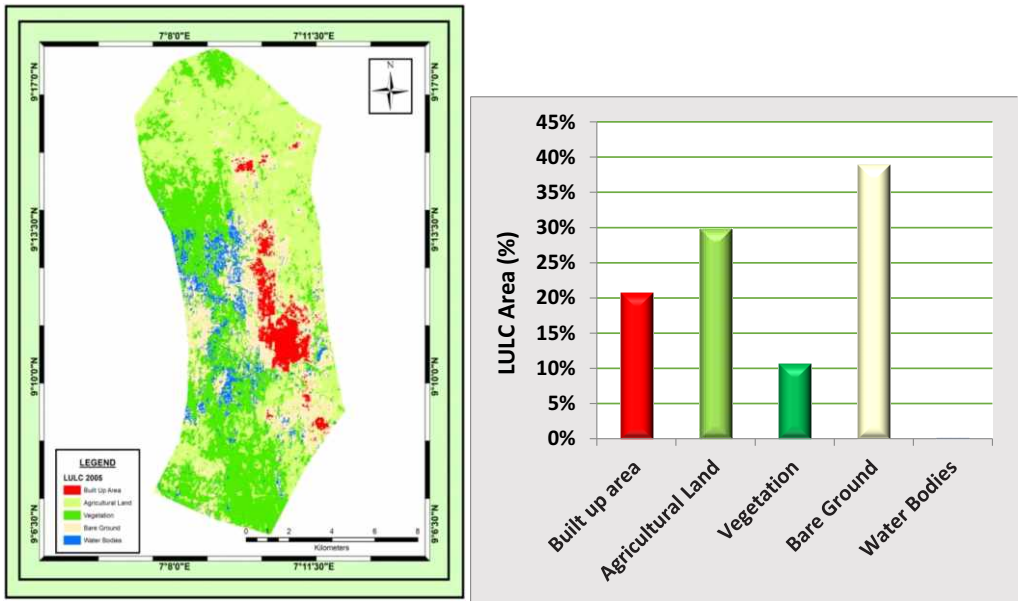

Figure 4: Land-use Land cover map of Suleja in 2005

Change detection between 1990-2005

The 1990-2005 analysis shown in Figures 3 and 4 revealed that the built-up areas increased at the rate of 5.2% from 1990-2005, while the open spaces also increased at 26.7%. The table further shows that other land uses, such as vegetation and bare ground, decreased at 22.0% and 10.1%, respectively.

The change detection between classified images of 1990 and 2005, as shown in Figure 3, revealed the growth in built-up areas towards the edges of the main towns. Settlements have developed around the northern part of Madalla, Kwamba, Gauraka and sparsely around Bakin Iku, Rafin Sanyi, and Diko.

Urban sprawl and land use change in Suleja from 2005-2020

The 2005 and 2020 analysis shown in figure 5 shows that vegetative cover and open space still occupied the highest class with 4193.1 hectares (25.1%) and 7709.2 hectares (38.0%) in 2005, 5426.5 hectares (26.8%) and 6932.5 hectares (34.2%) in 2005 respectively of the total class, taking up more than half of the entire classes combined. Furthermore, the built-up area recorded 2552.0 hectares (7.9%) in 2005 and 4346.7 hectares (17.5%).

Change detection between 2005-2020

Figure 5 revealed that the built-up areas increased from 2552.0 hectares in 2005 to 4346.6 hectares in 2015 at 9.6%, while vegetation slightly increased from 4193.1 hectares in 2005 to 5426.4 hectares in 2015 at 1.59%. Table 2 further shows that open spaces and bare ground decreased from 7709.2 hectares to 6932.5 hectares at the rate of 3.8% and 5806.4 to 3556.1 hectares at 7.2%, respectively. Change detection between 2005-2020 in Figure 5 shows the changes in land use categories in the study area. The figure further revealed the scattered expansion of settlement towards and around Madalla, Kwamba, Bakin Ikuand Gauraka.

Table 1: Changes in Land use in 1990 - 2005

Land use	Ares in Hectares		Increase / Decrease	% Rate
	1990	2005		
Vegetation	17418	4193.1	Decreased	21.97
Open Spaces	2292.77	7709.2	Increased	26.73
Bare Ground	7865.12	5806.4	Decreased	10.13
Built up	555.66	2552	Increased	5.15

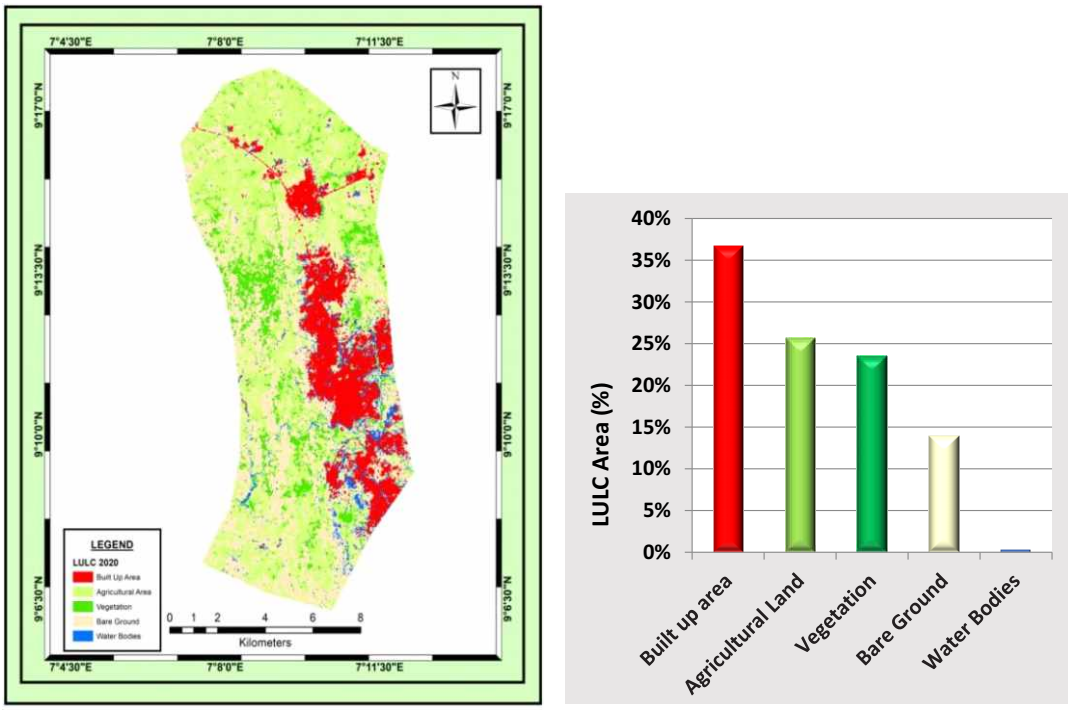

Figure 5: Land-Use Land cover Map of Suleja in 2020

In 2020, the urban expansion in Suleja grew, shifting settlements towards the town's edges. Neighbourhoods like Gauraka, southeastern Diko, North of Bakin Iku, eastern Madalla and Rafin Sanyi witnessed new dimensions of settlements expansion. Vegetative areas, mainly around western to southern Kwamba, remained unchanged between 2005 and 2020, as did some other noticeable regions around the study area. The surrounding built-up areas of major neighbourhoods represented in cream colour show the increase in built-up areas. In contrast, the intermediary green colour shows areas that remained unchanged. Changes from rock outcrops and vegetation to open spaces were noticed around Maje, Diko, Kwamba and Gauraka, with traces around Bakin Iku and Rafin Sanyi.

Table 2: Changes in Land use in 2005-2020

Land use	Area in Hectares		Increase/ Decrease	% Rate
	2005	2020		
Vegetation	4193.07	5426.45	Increased	1.59
Open spaces	7709.23	6932.52	Decreased	3.81
Rock outcrop	5806.46	3556.08	Decreased	7.18
Built up	2552.00	4346.65	Increased	9.64

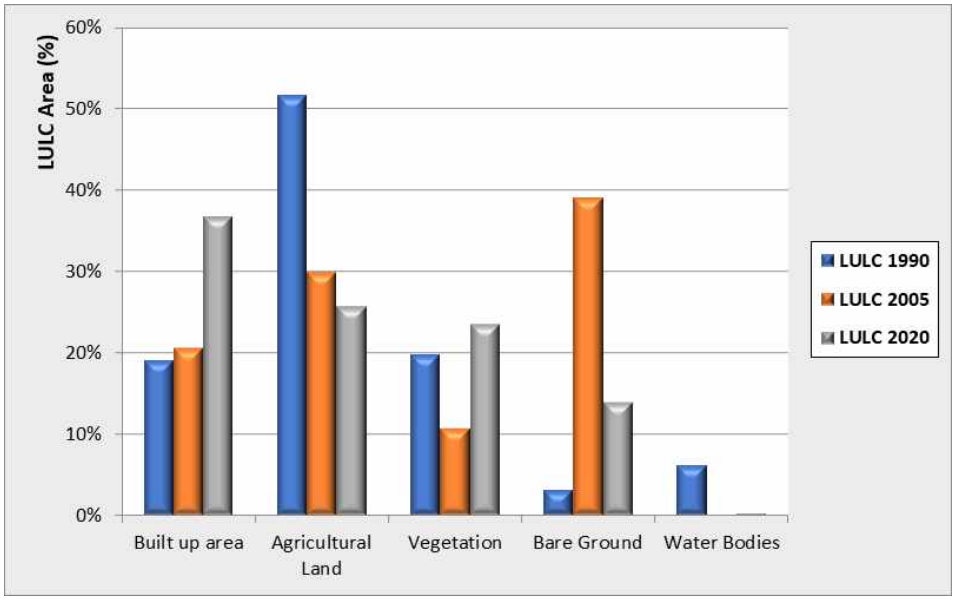

Figure 6: Cumulative of Land use land cover between 1990 - 2020

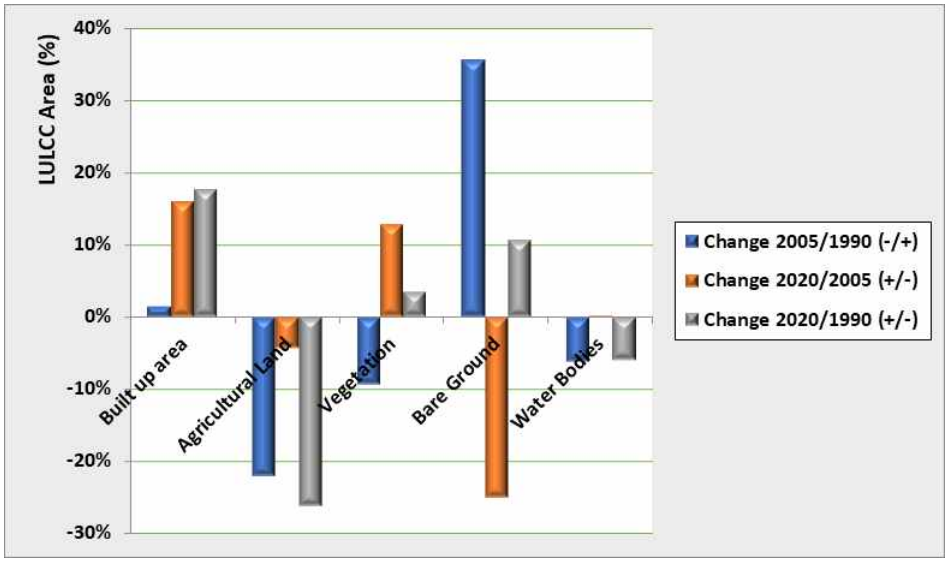

Figure 7: Cumulative Land-use land cover change and trends between 1990 - 2020

Magnitude of change in land use/ land cover (1990-2005)

In the thirty (30) years interval between 1990 and 2020, both positive and negative changes in land use and land cover categories were experienced. Figure 6 reveals the magnitude of changes that occurred in land use from 1990-2020. It was observed from the analysis that in 1990-2005 vegetation and bare land recorded a negative change of -13224.9 and -2058.8, respectively, while the open space and built-up areas recorded a positive change of 5416.5 and 1996.4, correspondingly. From 2005-2020, the analysis indicated that vegetation and built-up areas experienced a positive change of 1233.4 and 1794.6, respectively. The investigation revealed that only bare ground recorded a negative change of -213.33 while vegetation and built-up areas changed positively at different magnitudes 1012.6, 1040.13 and 1366.1, respectively.

The findings from data analysis of Urban sprawl and land use/land cover, spatio-temporal changes within the years under study, and the population trends as it affects the development of the peri-urban area. The analysis obtained from GIS analysis made on the Landsat imagery of the selected area shows that the built-up area has increased from 555.66 hectares in 1990 to 2552.00 hectares in 2005 at the rate of 5.15%, within the period of 30 years (1990-2020) the built-up areas grew from 555.66 hectares to 5712.75 hectares at the rate of 25.48%. From the change detection analysis, there was a significant threat to urban growth in many ways than one to the city and environs, such as the clearing of natural vegetation and its replacement with other activities, mainly residential development. There has been a marked decrease in vegetation, a major threat to biodiversity and many cause species extinctions by reducing and fragmenting existing habitats.

Conclusion and Recommendation

The research has analysed urban sprawl in the peri-urban area of Suleja. It has been concluded that the area is undergoing sprawl in the built-up land. Therefore, monitoring of rapid urban growth as evidenced by changes in land use in this study is a major concern that has been frustrated by the lack of up-to-date information on changes in urban land use. Such information is necessary to provide a basis for a more practical understanding and management of the urban environment. This research work demonstrates the ability of GIS and Remote Sensing techniques to measure change patterns of urban land use even in traditional unplanned settlements. However, for effective and functional urban growth management, data is required on changes within and around the cities. Such data is vital to urban development and preventing uncontrolled expansion and its consequences. For instance, land use changes require continuous updating of lands and their analysis to determine the rates and direction of city growth for planning. This study recommends upgrading the selected peri-urban areas of Suleja by providing city-wide infrastructures like the source of water supply, waste management facilities, community centre, community market and playground/recreational facilities that is required to meet the needs of the people.

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