



## Depletion of Urban Green Spaces in Jos Metropolis, Nigeria

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### ABSTRACT

*This paper analyzed the rate of depletion of green spaces in Jos metropolis from 1990 to 2021. Data on the Urban green spaces of Jos metropolis for the years 1990 to 2002, 2002-2013 and 2013 to 2021 were acquired from United State Geological Survey Earth Explorer free Online Data Service (<https://earthexplorer.usgs.gov/>). Landat-4 Thematic Mapper (TM), Landsat-7 Enhanced Thematic Mapper (ETM), Landsat-8 Operational Land Imager, Thermal Infrared Sensor (Landsat-8 OLI/TIRS) and ArcGIS10.5 aided classification of land use and land cover (LULC), re-geo-referencing and rectification. Depletion and Regeneration models were also to analyze the depletion rate of green spaces. A total of 28 images were captured for the dry season to minimize the availability of haze and to obtain cloud-free satellite images. The study revealed spatiotemporal dynamics in the Landscape, the built-up areas experienced an increase from 17.36% in 1990 to 44.99% in 2021, and the green spaces decreased from 33.56% in 1990 to 14.35% in 2013 but slightly rose to 17.78% in 2021 due to increased awareness for landscaping and horticultural activities, while, bare land and water body experienced fluctuations. By extension, the green spaces were reduced from 8,375.31 Ha to 3,579.75 Ha at a depletion rate of 40.12%. Urban Sprawl at the fringes, immigration due to insecurity, and ineffective development control account for the aforementioned situation. However, urban agriculture, fruit tree planting, Horticulture and landscaping increased green spaces by 27.9% from 2013-2021. The greens are most likely to experience greater depletion with the rising insecurity and the large migration rates, coupled with rapid urban development, except efforts to galvanize greens through campaigns and urban agriculture are sustained. The paper recommends a functional Spatial Plan to include green infrastructure and provide a framework for an efficient and effective physical development to minimize encroachment into the green spaces and reserves.*

**Keywords:** Depletion, Urban Green Space, Green infrastructure, Remote Sensing, Vegetation

### 1. INTRODUCTION

Urban growth has been considered undesirable due to the negative impact on the environment, natural resources, human health and socio-economic problems, decrease in agricultural lands, wild forests and open spaces that are associated with it (Adzande, Akintunde & Akintunde, 2015). Several

types of research on environmental impacts have alluded to the fact that urban growth exerts pressure on undeveloped green spaces through rapid urban development and competition for land uses located in choice areas (Vargas-Hernández, Pallagst & Laska, 2018). Similarly, the works of Rikko and Dung Gwom (2019) on the Challenges

of Urban growth in Greater Karu Urban Area, Nigeria, revealed a rapid decline in agricultural land and vegetation resources due largely to rapid urban development and unprecedented urbanization. The intensity of pressure on green spaces for different human activities has resulted in persistent deterioration of these spaces, especially in urban areas where the pressure is more profound (Cilliers., Lubbe, & Siebert, 2012; Rikko & Laka 2013). Some studies have shown that as green spaces deplete, permeable spaces correspondingly declined within the same period, particularly where urban development is unplanned and unregulated, enhancing urban sprawl and further depletion of green areas (Amoako & Korboe, 2011; Areola & Ikporukpo, 2020). Even in the planned city of Abuja, the Federal Capital of Nigeria, Uwerunonye (2020) observed that the designated green spaces on the master plan have already been overtaken by illegal activities and shanty development which is a response to compliment housing deficit for the low- and medium-income group due to high cost of housing accommodation and ineffective plan implementation. In turn, the aforementioned argument may negate the achievement of Sustainable Development Goals (SDGs) 2 and 15 on ending hunger, achieving food security, improving nutrition and promoting sustainability and promotion of sustainable ecosystems to halt biodiversity loss (United Nations, 2019).

The term “green space” is a recent term often used interchangeably with open spaces in urban planning. Urban green space (UGS) has been defined as the natural environment in the city connecting humans with nature such as parks, forests, grasslands, river corridors, and wetlands (Wolch, Byrne, & Newell, 2014; Yiyi *et al.*, 2021). It may consist of all vegetated areas that are naturally or artificially covered with vegetation (Fratini & Marone, 2011) such as trees, shrubs, grasses or forests, parks, allotments and cemeteries (Ikporukpo, 2020). Others have expanded the definition to cover all green infrastructure such as the network of the natural, semi-natural and artificial ecological systems within a given area (Mensah, 2014; Sandström, 2002). These areas according to Langer and McNamara (2011) may be residential, institutional and industrial; parks, street trees and roadside plantations; public green areas, public

and private tree plantations on vacant lots, green belts, woodlands and peri-urban farming; rangeland and forests close to urban areas; natural forest under the urban influence such as nature reserves, national parks, and forests for eco-tourism; and Trees planted for environmental protection and beautification. They could even be made up of the built environment and the external environment between buildings as perceived by Swanwick., Dunnett, and Woolley (2003). For the purpose of this paper, all the definitions are considered as relevant in assessing the general green spaces within Jos metropolis between the period of 1990 to 2021.

Scheer (2001) referred to green spaces as the “Lungs of the city” because the greens produce oxygen which helps to filter out harmful pollutants and dust from the air, provide shade and lower temperatures in urban areas, public health safety, cool gas tanks on car parks and lowers evaporative emissions of volatile organic compounds (VOCs). Air pollutants such as Carbon monoxide and Carbon dioxide are usually at low levels in areas with thick vegetation/urban green (Habila, Oladimeji & Rikko, 2020). Greens also provide areas for recreation, some physical activities and control of soil erosion along waterways. In addition, greens reduce urban noise, increase property values, decrease stress and aggressive behaviour and increase the aesthetic environment of our cities. Twohig-Bennett & Jones (2018) also portray the capability of greens to ameliorate acute stresses, balance psychological distress and improve healthy well-being, especially during Pandemics and stressful events. For instance, experts in Public Health and Epidemiology have observed that parks and public gardens help people to cope with stressors such as covid-19, anxiety, depression, loneliness, low- self-esteem, grief, anger and other health challenges associated with urban living (Violeta *et al.*, 2021). Others have reiterated that moderate physical outdoor activity during periods of mobility restrictions, such as exercise in nearby urban forests, is known to deliver important benefits to physical and mental health (Fröhlauf *et al.*, 2020). Other Authors ascertained that mere window views of green spaces from indoors/ within the home increased some levels of self-esteem, life satisfaction, subjective happiness and decreased levels of

depression, anxiety and loneliness (Soga *et al.*, 2020).

On the other hand, green spaces are a great motivation for real estate markets, and good environmental quality attracts higher rental value with more clients willing to pay more for urban properties located close to UGS (Luttk, 2002; Jim & Chen, 2010). Consequently, many cities in developed countries make efforts to incorporate greens in city planning, particularly in parks in poor neighbourhoods (Wolch, Byrne & Newell, 2014). Landscape planning has been a vital aspect of city planning since the 19<sup>th</sup> Century and has become a social necessity (Essel, 2017). Some planning concepts such as garden city, green belt, green fingers and greenways had highlighted the need to preserve the natural environment of urban areas by incorporating many green spaces into the design of cities (Mensah, 2014). However, landscape planning in developing countries is yet to receive focus and recognition perhaps because its economic value is not as immediately recognizable due to the absence of its market prices (Yuhan *et al.*, 2020). This could explain some of the reasons that greens are under intense pressure from other land uses that are considered of higher value and rents in the city. The adverse effect of the decline in green spaces has been evident in high temperatures, urban heat island effect, unattractive environment, atmospheric pollution and decrease in life expectancy in urban areas especially in poor and developing countries.

In Jos metropolis, green spaces have experienced more intense depletion in the past two decades largely due to increased anthropogenic activities that drive changes in land use and land cover. The rapid rate of urbanization and urban growth in addition to the incessant conflicts and insecurity has been associated with a high rate of uncontrolled and unplanned residential housing development which has exerted much pressure through the intense use of green spaces in the metropolis. Experiential evidence has shown that green spaces earmarked by the Jos Master plan (Dioxidis, 1975) for landscaping since 1975 were never developed nor preserved neither nor was the policy on preservation and reservation effectively implemented. These have led to the depletion of green parks, nature reserves, hilltop areas, botanical gardens, urban street trees and

neighbourhood gardens through encroachment by housing and urban development, felling of trees for fuel and lumbering. On the other hand, Rikko and Dung Gwom (2019) asserted that an increase in population growth, high demand for housing accommodation and increase in commercial activities trigger depletion of a landscape while, Shitnaan (2022) found out in his work on 'Green Infrastructure in Jos Metropolis, Nigeria' that incessant conflicts and residential mobility as well as poor, ineffective planning and institutional management of the landscape, as well as poor, ineffective planning and institutional management of the landscape, are major contributory factors to the current changes in the landscape.

These scenarios have triggered the need to analyze the rate of depletion of green spaces in Jos metropolis and its implications on their sustainability. This is because the provision, design, management and protection of urban green spaces are at the top of the agenda of sustainability and liveability. Urban green spaces play a key role in improving the liveability of our towns and cities. The quality and viability of cities largely depend on the design, management and maintenance of green as well as open and public spaces to fulfil their role as an important social and visual focus (Sati, 2013). Urban green spaces are not only an important component in housing areas; but also in business, leisure, retail and other commercial development.

## 2. MATERIAL AND METHODS

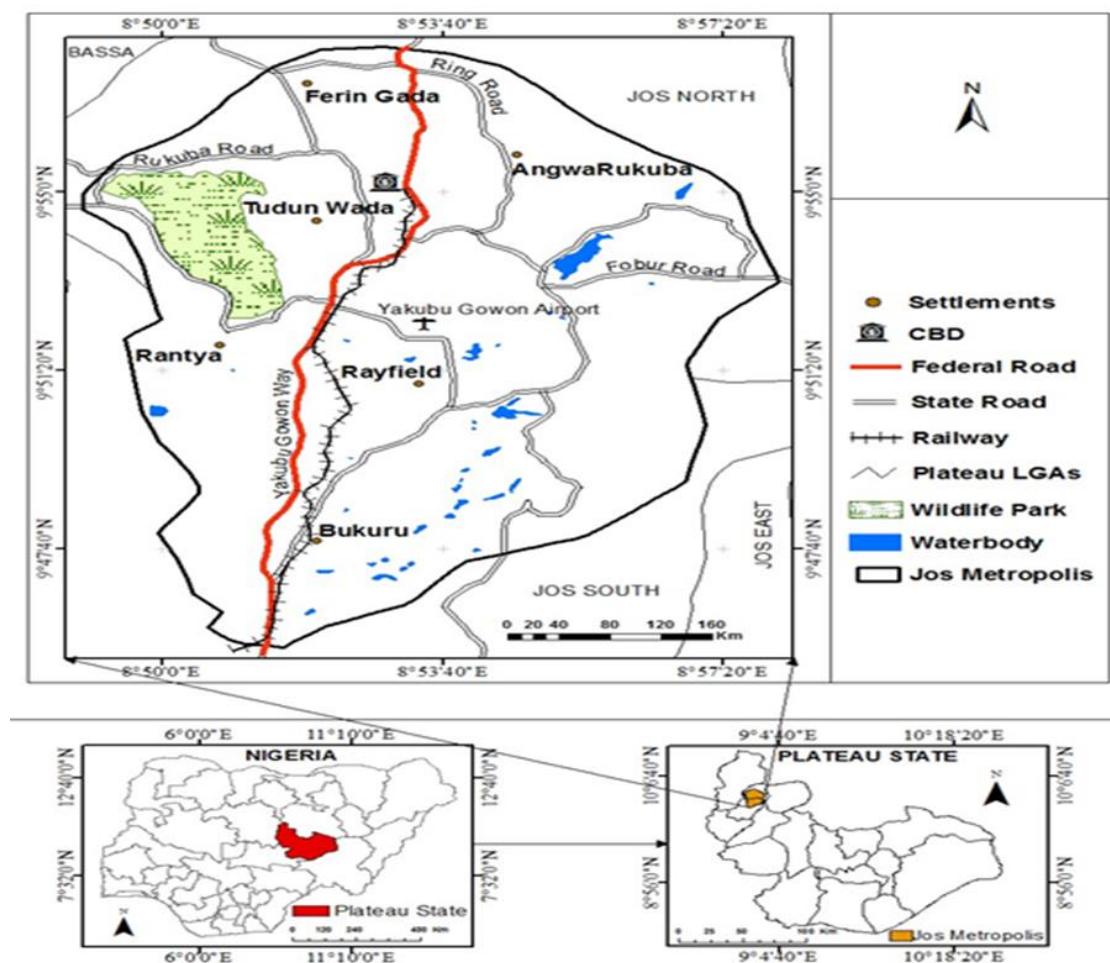
### 2.1 The Study Area

Jos Metropolis consists of two Local Government Areas of Jos North and Jos South (Figure 1 as demarcated by the Jos Metropolitan Development Board Edict No.5 of 1974). Jos, is the administrative headquarters of Plateau state with a current population of about 2 million people NPC, 2019). Jos metropolis covers an area of 249.7km<sup>2</sup>, with an altitude of 1,217m (3,993ft) above sea level. It lies within latitudes 9°45'00"N to 09°57'00"N and longitudes 8°48'00"E to 8°58'00"E and has a cool climate with an average monthly temperatures ranging between 21°C and 25°C, with average humidity of 60% and rainfall of 1,400mm. The metropolis is characterized by undulating surfaces and isolated rocky outcrops with a variety of landforms. The near temperate climate enhances

the thriving of exotic vegetation cover in both temperate and tropical climates. The climate is the wet and dry type classified as tropical rainy climate and characterized by a mean annual rainfall of 1,250mm, peaking between July and August. The mean average annual temperature is about 22°C but means monthly values vary between 19°C in the coolest month of December and 25°C in the hottest month, April. Like most cities in Nigeria, Jos is experiencing an unprecedented urban expansion. According to the 2006 census, the population of Jos was 950,000 but the current estimate shows the population of Jos to be about 1.7m (NPC, 2019). This is attributed largely to the unprecedented flux due to rural-urban and urban-urban migration fueled by insecurity in the state and elsewhere in Nigeria in the last two decades.

## 2.2 Method of Data Collection

This study employed Satellite remote sensing data for the analysis of the depletion of green spaces in Jos Metropolis. Landat-4 Thematic Mapper (TM), Landsat-7 Enhanced Thematic Mapper (ETM), Landsat-8 Operational Land Imager and Thermal Infrared Sensor (Landsat-8 OLI/TIRS) as presented in Table 1 covering Jos Metropolis were acquired from United State Geological Survey Earth Explorer free Online Data Service (<https://earthexplorer.usgs.gov/>) for land use/land cover classification analysis for three epoch periods (between 1990 to 2002, 2002 to 2013 and 2013 to 2021 (31years) with approximately 10-year intervals. A total of 28 images were downloaded for the selected years captured under the dry season to minimize the



**Figure 1: Description of the study area**

*Source: Department of Urban and Regional Planning, University of Jos, 2021*

**Table 1:** Satellite Images used for the Study

S/N	Satellite Image	Censor ID	Resolution	Date Acquired	Path & Raw	Spatial Ref.	Source
1	Landsat 4	TM	30*30	22/12/1990	188/053	UTM/WGS,1984, ZONE 32N	USGS
2	Landsat 7	ETM	30*30	06/02/2002	188/053	UTM/WGS,1984, ZONE 32N	USGS
3	Landsat 8	OLI TRS	30*30	10/04/2013	188/053	UTM/WGS,1984, ZONE 32N	USGS
4	Landsat 8	OLI TRS	30*30	02/02/2021	188/053	UTM/WGS,1984, ZONE 32N	USGS
5	Landsat 4-9	Google earth	10,000	17/01/2022	188/053	UTM/WGS,1984, ZONE 32N	Google earth pro
6	Landsat 4-9	Shape files	1:2,000	05/12/2021	188/053	UTM/WGS,1984, ZONE 32N	ArcGIS 10.5

**Table 2:** Landuse/Land cover classification

No	Classification	Description
1	<b>Bare Land</b>	This includes a Natural outcrops, uncultivated lands and plain lands.
1.	<b>Built-up</b>	This includes all physical infrastructure such as residential buildings, school buildings, government and administrative buildings, Hospital buildings, commercial buildings, industrial and manufacturing structures, parking spaces, tarred surfaces, Bus stations, Airports, rail lines, pedestrians, etcetera.
1.	<b>Green Space</b>	This includes all green belts, parks, gardens, natural vegetation, farm lands, cemeteries, woodland, open spaces, game reserves, forest, botanical gardens, recreational gardens, outdoor play areas etcetera.
1.	<b>Water Body</b>	This includes rivers, streams, ponds, dams, springs etcetera.

availability of haze and to obtain cloud-free satellite images of the study area. Google Earth Pro was used to acquire satellite images and then a series of interpolations and manipulations were employed using ArcGIS 10.5. It was then projected onto the Universal Transverse Mercator (UTM) of WGS 1984 and Datum Zone 32 in which Jos metropolis lies. To enable overlay of imageries for various years, epochs of images which had different spatial resolutions (geo-reference properties) from others were re-georeferenced to the same reference and rectified. Four stages of spatial data analysis methods were adopted, namely: Image Resampling, supervised (Maximum Likelihood) Classification employed due to its ability to consider the spectral variations within each category and the overlapping coverage of the different classes, Calculation of the Area in hectares and overlay operations. Each image epoch analyzed revealed some dynamics between land cover over time and space. A Landuse Land cover was classified into Four, namely: Bare surfaces, Built-up, Green Spaces, and water bodies (Table 2).

### 2.3 Depletion and Regeneration Models

The depletion model was employed to establish the area coverage of green space between the present year and the advanced year as a ratio to the area coverage of the present year and then

multiply it by 100 to produce a percentage depletion (decrease) of the green space while the regeneration model was used to show the difference in area coverage of green space between the advanced year and the present year as a ratio to the area coverage of the advanced year and then multiply it by 100 to produce a percentage regeneration (increase) in green spaces.

#### A. Percentage Depletion:

$$\frac{\text{Year (X-Y)}}{\text{Year Y}} \times 100$$

Where, X is the area of green space in the Present year, and Y is the area of green space in the Advanced year.

#### B. Percentage Regeneration:

$$\frac{\text{Year (Y-X)}}{\text{Year X}} \times 100$$

Where, X is the area of green space in the Present year, and Y is the area of green space in the Advanced year

## 3. RESULTS AND DISCUSSION

### 3.1 Spatiotemporal Land use changes.

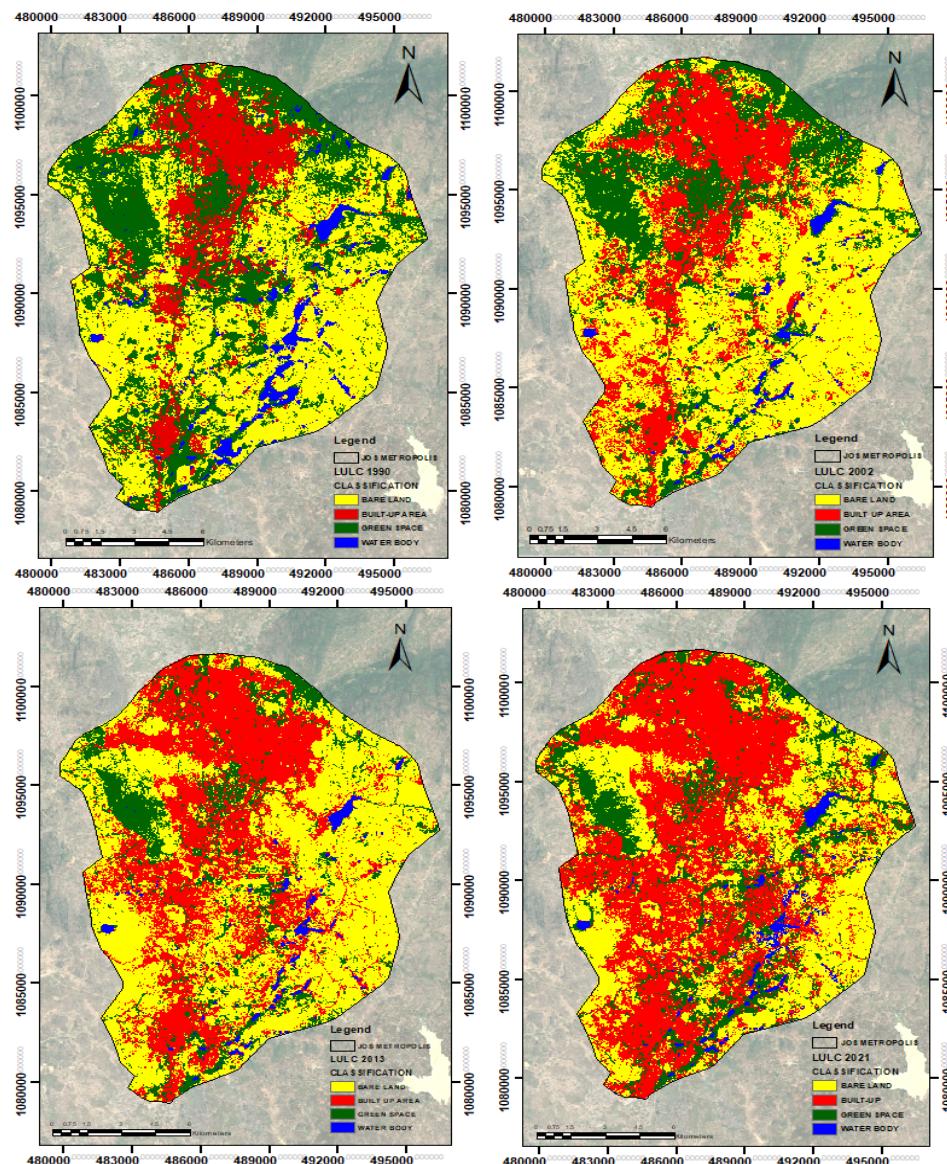
Table 4 presents the results of the classification for 1990, 2002, 2013 and 2021 satellite images. The result shows the spatial and temporal changes that have occurred in the landscape

between the 1990-2021 epoch period. While built-up experienced significant increases and expansion from 1990 to 2021, others such as green spaces, bare land and water body

experienced fluctuations in changes. For instance, Built-up areas experienced continuous increases from 17.36% in 1990 to 24.73% in 2002, 34.19% in 2013 and 44.99% in 2021, with

**Table 4: Land Use/Land Cover Change**

Land Type	Cover	1990 (Ha)	1990(%)	2002(Ha)	2002(%)	2013(Ha)	2013(%)	2021(Ha)	2021(%)
<b>Bare land</b>		11,235.69	45.03	12,403.62	49.71	12,436.47	49.84	8760.15	35.11
<b>Built-up area</b>		4,332.6	17.36	6,170.58	24.73	8,530.83	34.19	11226.33	44.99
<b>Green space</b>		8,375.31	33.56	5,978.7	23.96	3,579.75	14.35	4,437.72	17.78
<b>Water body</b>		1,009.53	4.05	400.23	1.60	406.08	1.63	528.93	2.12
<b>Total</b>		24,953.13	100.00	24,953.13	100.00	24,953.13	100.00	24,953.13	100.00



**Figure 4: Spatial distribution of Landuse in Jos Metropolis from (1990-2021).**

higher proportions recorded between 2013 and 2021, giving an increase of about 28% within the study period. Green spaces on the other hand decreased significantly from 33.56% in 1990 to 23.96% in 2002 and 14.35% in 2013 but slightly rose to 17.78% in 2021, an increase of 3.43%. Water bodies decreased from 4.05% in 1990 to 1.60% in 2002, and increased to 1.63% in 2013 and further increased to 2.12% in 2021, an increase of about 1.83%. Bare land on the other hand increased from 45.03% in 1990 to 49.71% in 2002 and from 49.84% in 2013 decreased significantly to 35.11% in 2021 a reduction of 14.73%. The dynamics in the Landuse/cover reflect the different activities that occurred encroaching and affecting various uses and landscapes within the different epoch periods.

### 3.2 Spatiotemporal Depletion and Regeneration of Green Space.

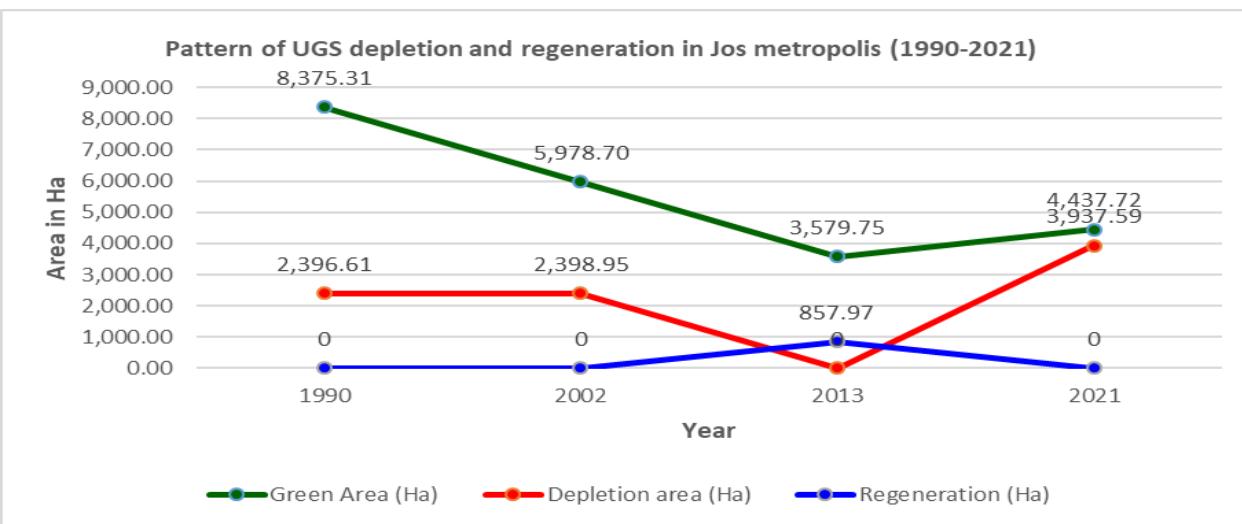
Table 5 results depicts the rate of depletion of green spaces using the regeneration model. This

model provides an understanding of the actual spatiotemporal changes of green space from 1990 to 2021. From 1990-2002, a reduction of 2,397.31 Ha (28.1%) was recorded from 8,375.31 Ha to 5,978.70 Ha. Between 2002-2013, there was a further reduction with an almost equal magnitude of 2398.95 Ha from 5,978.70 Ha to 3,579.75 Ha with a depletion rate of 40.12 % about twice the rate of depletion between 1990-2002. The general depletion of the green space during the study period reveals a decline of about 3,410.73 Ha accounting for about 41% as shown in Figures 6 & 7.

However, between the period 2013-2021, a regeneration in green space was observed with an increase of 1,384.25 Ha from 3,579.75 Ha to 4,964.58 Ha at 27.89%. This result is also corroborated by Shehu (2020) in his work on Urban Growth and Change Detection in Land Use Land Cover in Jos. He found that there was an increase in vegetation and green fields between 2013 and 2018.

**Table 5:** Pattern of UGS depletion and regeneration in Jos Metropolis (1990-2021)

Year	Green Area (Ha)	Time Series	Depletion Area (Ha)	Regeneration	% Depletion	% Regeneration
1990	8,375.31	1990-2002	2,396.61		28.61	
2002	5,978.70	2002-2013	2,398.95		40.12	
2013	3,579.75	2013-2021		857.97		19.33
2021	4,437.72	1990-2021	3,937.59		47.01	



**Figure 6:** Pattern of UGS Depletion and Regeneration in Jos Metropolis (1990-2021)

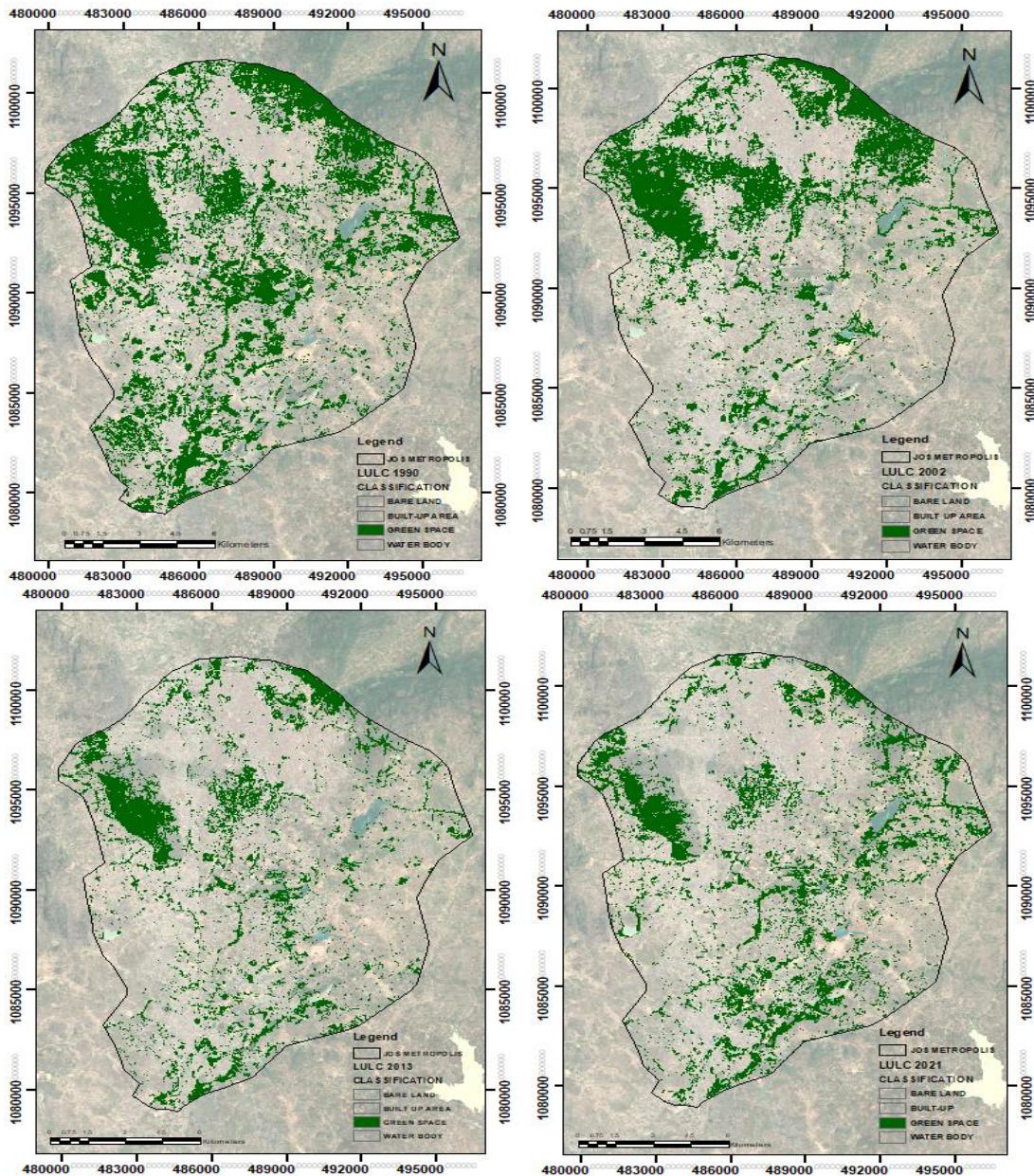


Figure 7: Spatial distribution of Green spaces in Jos metropolis from (1990-2021).

### 3.3 Factors Contributing to the dynamics of the Green Spaces

From 1990 to 2013, green spaces experienced rapid invasion and succession owing to the rapid housing and urban development leading to the sprawling of the metropolis in all directions. Between 2001 and 2013, about four major conflicts occurred in 2001, 2004, 2008 and 2012 with major consequences of loss of lives and property resulting in residential and business mobility to areas considered safe by residents

while abandoning houses and developing in unsafe areas. The rapid and unprepared nature of the movement triggered illegal, unplanned and uncontrolled expansion of residential housing mainly along the peripheries (Rikko, Pam, Namo & Tupkop, 2022) taking over green spaces where urban agriculture and cultivation occurred. This perhaps explains one of the reasons for the 40.12% high depletion in green space between 2002 to 2013. More so, that the city has experienced an unprecedented influx and immigration as a result of the insecurity that has

ravaged the rural communities of the state as well as the Northern part of Nigeria making Jos a hub and refuge for many requiring housing accommodation. It is interesting to note that despite the number of conflicts in Jos, the city has remained the best choice for many due to the natural endowments of the temperate climate and weather (which enhances good health from many ailments), beautiful rock outcrops, fertile soil and hospitality of the citizens in addition to the prosperity and blessings in the land which makes businesses to thrive. Rikko and Dung Gwom (2019) have asserted that an increase in population growth, high demand for housing accommodation and increase in commercial activities triggered depletion of the landscape in the metropolis.

Additionally, the study discovered that since the Master plan of Doxiadis in 1975, the policy on green spaces meant to ensure the preservation, conservation and preservation was not effectively developed nor was it effectively implemented, and there has been no further policy action mandating any agency or ministry with such responsibility after that. Wapwera and Egbu (2013) noted that the absence of a dedicated agency or ministry responsible for the management of urban green spaces within the metropolis made their conversion to other land uses unstoppable. Thus, green spaces have been vulnerable to the invasion of other uses that can pay higher rental values such as commercial, public, religious and health use competing for prime locations within the city. Anthropogenic activities on Green infrastructures such as parks, public gardens, zoological gardens, and Wild-life parks amongst others have been encroached into and some have completely taken over and by extension, erode the existence and health of ecosystems that several species depend on (United Nations, 2019). Shitnan (2022) also opined that the weak and ineffective planning and institutional framework for the management of green spaces make their depletion inevitable.

On the other hand, the increase and regeneration from 2013 to 2021 could be attributed to several variables. For instance, in 2017, there was conscious sensitization and a campaign by the state government and NGOs on the need for greeneries in the city due to the rapid rate of

depletion that had been prominent. The goal was to encourage the planting of economic and fruit trees in private houses, and landscaping of school environments and public places (especially during World Environment Day). The Jos Metropolitan Development Board also initiated an urban development policy on the inclusion of landscape design in every building plan as a requirement for approvals of building plans. These were deliberate efforts intended to galvanize greens in the metropolis.

Circumstantial evidence also shows that there has been increased urban agriculture in the last decade. This is partly due to the Economic Recovery program of the present administration to revamp the internal agricultural sector and minimize the importation of food, majorly due to the high and increasing rate of inflation and poverty which has thrown more than a 95million Nigerians under the poverty line with an unemployment rate of about 34% (Sasu, 2022). These have forced the unemployed youths and several low and medium income households into farming (both wet and dry seasons) using every available space such as abandoned relicts and undeveloped pockets of parcels of lands to meet the high demand for food both for their households and to service the growing market for farm produce both in Jos and elsewhere in the country. In addition, because of the temperate climate of the Plateau and the presence of abandoned mined ponds, several crops, vegetables and exotic flowers (horticulture) that only thrive in this environment are now cultivated both in dry and wet seasons. These also have galvanized the gradual regeneration of the vegetal cover and enhanced green spaces that have been depleted over the years.

#### 4. CONCLUSION

The paper has ascertained the state of Green Spaces in Jos Metropolis from 1990 to 2021. The results revealed some dynamics in the land use land cover with interesting variations between the epochs. The built-up areas continued to increase, while the green spaces experienced rapid depletion due to the expansion and sprawl of the metropolis from rapid urbanization, unprecedented population growth and rise in economic activities. The greens are most likely to

experience greater depletion with the rising insecurity and the migration of people in large numbers into the metropolis. However, the following efforts if put in place such as, formulation of policies, strategically sound institutional framework, innovative and creative drive such as sensitization and education through community participation, mobilization of capital and skilled human resources, sophisticated machinery and tools to adequately and functionally control, monitor, direct and implement holistic urban physical infrastructural development by the government can help in mitigating the depletion of greens and in the long run achieve the SDGs. This can be achieved if there is a functional Master Plan which would include green infrastructure and provide a framework for an efficient and effective physical development that will minimize encroachment into the green spaces and reserves. The provision of green planning education for the metropolis and city managers, developers and the public in the metropolis is required.

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