

# Effects of Urbanization on Jos Wildlife Park and Environs Using Geospatial Technology

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**Abstract:** Urbanization poses a significant threat to protected ecosystems, particularly in rapidly growing cities. This study assessed the effects of urbanization on land use/land cover (LULC) dynamics and habitat integrity of Jos Wildlife Park and its environs, Plateau State, Nigeria, over a 35-year period (1988–2023). Using multi-temporal Landsat satellite imageries (TM, ETM+, and OLI/TIRS) integrated with Geographic Information System (GIS) techniques, supervised classification was employed to map and quantify changes in five major LULC classes: vegetation, built-up areas, farmland, bare land, and rocky outcrops. Ground truthing using GPS data and high-resolution imagery supported classification accuracy assessment.

The results revealed pronounced urban-induced landscape transformation within and around the park. Vegetation cover declined drastically from 904.70 ha (52.51%) in 1988 to 390.15 ha (22.65%) in 2023, representing a net loss of 514.55 ha (−40.31%). Conversely, built-up areas expanded substantially from 84.96 ha (4.93%) to 538.65 ha (31.27%), while farmland increased from 192.24 ha (11.16%) to 376.85 ha (21.87%) over the same period. Rocky outcrops and bare land also experienced net declines, reflecting intensified land conversion pressures. Decadal analysis showed consistent increases in built-up and agricultural land at the expense of natural vegetation, indicating accelerating anthropogenic encroachment. Classification accuracy was acceptable, with overall accuracies ranging from 83.75% to 95.63%, confirming the reliability of the results.

The observed LULC changes underscore the adverse impacts of unchecked urban expansion, agricultural intensification, and deforestation on wildlife habitats and biodiversity conservation in Jos Wildlife Park. The study highlights an urgent need for strengthened land-use planning, effective buffer-zone management, public awareness, and improved conservation strategies to mitigate urban pressures and ensure the long-term sustainability of this critical protected area.

**Keywords:** Urbanization, Vegetation Cover, Forest Change, Wildlife Park, Environments.

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## I. INTRODUCTION

The Jos Wildlife Park harbours a large number of plants and animal species, the park, is a protected area that provides a natural habitat for many biological species. In this protected habitat, wildlife and habitat of many biological diversity are faced with human activities. These anthropogenic activities include deforestation, agricultural activities, urban expansion and predation by domestic animals (Chaskda and Fandip, 2017; Kanianska, 2016). One of the impacts of urbanization is the destruction of natural ecosystems and habitats of large number of species are one of the biggest threats to global

biodiversity and the planet earth. Particularly, this has been through rapid deforestation to meet the rising demand for agricultural land, settlement, domestic fuel, and timber as a result of explosive human population growth. (Mittermeier *et al.*, 2007). This study assessed the effects of urbanization on land use/land cover (LULC) dynamics and habitat integrity of Jos Wildlife Park and its environs using geospatial analysis of land use land cover changes over the period of 35 years in Jos wildlife Park.

## II. REVIEW OF LITERATURE

The Jos Wildlife Park is faced with anthropogenic activities, like any other protected area in Nigeria that poised threats on the survival of biodiversity. Human activities have accelerated the species extinction process by destroying the natural environment and degrading species habitats. Habitat destruction is often considered to be the most critical factor endangering biodiversity of the world (Michalski and Peres, 2005). These have impacted negatively on the natural habitat of biodiversity, and urbanization is at the root of wildlife habitat destruction and threats to species existence globally (Foley *et al.*, 2005; Chaskda and Fandip, 2017). These human are increasing on a daily bases as a result of increase in human population size. Urbanization is one of the major causes of habitats and biodiversity loss. For instance, land development, construction and land clearing for agricultural practices has affected wildlife by direct wildlife habitat loss.

Jos wildlife Park harbours a number of plant and animals species that require a holistic protection from these human activities. Jos metropolis, comprising of Jos North and Jos South built-up areas, is a mid-sized city that has experienced the pressures of rapid population growth and urbanization (Adzandeh, Akintunde, & Akintunde, 2015); these has led to increased pressures on hitherto vacant lands as the need for housing and other urban amenities increase. While increased urbanization is a global trend, with the global urban population rising from a lowly 14% in the early 1900s to 50.5% in 2010 (Seifoddini & Mansourian, 2014), and still projected to keep rising; this urban growth if unchecked has a negative effect on the environment, human health and natural resources. Such negative impacts include reductions in open spaces, cultivable land, natural forests and increase in environmental pollution. A major effect of urbanization is bush encroachment, which reduces plant cover and carrying capacity for animals in previously undisturbed locales (Iirmdu, *et al.*, 2013). Bush encroachment itself whose effects are compounded by subsistence agriculture also has several drivers, chief amongst them are disturbance and land use history (Hoffman, *et al.*, 2014).

In simple terms, urbanization can be looked at as the process wherein substantial numbers of people gradually become concentrated in relatively small areas, with city formation being the end result (Encyclopedia Britannica). Just as with any other process, there are a myriad of factors that shape and affect the direction of urbanization in any given society, some of the most crucial ones include industrialization, globalization, marketization, and administrative/institutional power (Gu, 2019). All these factors have seemingly contributed to the increased pressure on the study area due to the rapid urbanization of surrounding areas. While the rate of industrialization has unfortunately reduced due to the decline of tin mining activities on the Jos Plateau, the population of immigrants have stayed on and pivoted to other vocations/employment routes; the Federal and State Secretariat complexes located in neighboring Tudun Wada provides employment to a good number of civil servants, hence attracting population to the area. Improvements in road transport network have also allowed

people that work closer to the town centre to be able to move to the more serene areas close to the park while still enjoying easy commutes to and fro their offices.

Several studies have demonstrated that unchecked urbanization leads to a decline in ecosystem abundance and biodiversity, mainly due to the conversion of those ecological zones into impermeable surfaces (Amundson, *et al.*, 2015). As urban areas continue to expand, pressure on existing green areas increase as well, the land is needed for housing, the trees are needed for construction and furniture; and in the case of the locales surrounding the study area, and some families need forest resources for sustenance. Biodiversity is one of the key indicators of a healthy ecosystem, and also one of the most attractive features of a park for tourists, but as (Kondratyeva, *et al.*, 2020) opined: “urbanization is one of the most intensive and rapid human-driven factors that threat biodiversity”. The interaction between urbanization and biodiversity is oftentimes multifaceted and complex, but more often than not, the continued expansion of urban is a major threat to native endemic species due to increased instances of colonization by introduced invasive species that threatened the delicate ecological balance hitherto obtained in an ecosystem (McKinney, 2002; McKinney, 2008).

In the long run, urbanization impacts ecosystems both directly and indirectly. Direct impacts consist primarily of habitat losses and degradation, modified soils, and other physical transformations caused by expansion of urban centres. Indirect impacts on the other hand include, but are not limited to, changes in water nutrient availability, increase in a biotic stressors such as air pollution, competition from invasive species, and changes in herbivory and predation rates and habits (Pickett & Cadenasso, 2009; Seto, *et al.*, 2015)

## III. MATERIALS AND METHODS

### ➤ Study Area

The study was carried out at the Jos wildlife park, Plateau State, Nigeria. The Jos Wildlife Park is a protected area owned by plateau State government and managed by Plateau State Tourism Cooperation. The Jos Wildlife Park is located to the South West of Jos, Plateau State, Nigeria along the Jos-Miango road, about five (5) Kilometers from the city of Jos. The park is bounded in the North by Tudun wada in Jos north LGA, while in the south by Federal Low-cost Rantiya respectively, in Jos North Local Government Area of Plateau state. (Ijeomah *et al.*, 2005; Chaskda and Fandip, 2017). The Jos Wildlife Park covers a total area of 8 Km<sup>2</sup> with a geographic coordinates located between latitude (9° 46' 00" and 9° 52' 00"N) and longitude (8° 48' 00" and 8° 52' 00"E) with an altitude that ranges from 1,300-1,500m above sea level. The park is characterized hilly and rocky topography with seasonal streams, savannah woodland and gallery forest (Barbour, 1982; Ijeomah *et al.*, 2005).

The entire park lies within the northern guinea savanna, the area has a tropical climate with two distinct seasons; wet and dry. The wet season extends from the month of April to October and the dry season begins from November and ends

in March. The area experiences the mean annual rainfall ranging from 1,000 to 1,400mm. The area has more cold weather than most parts of Nigeria on the same latitude, it is

characterized with an Average monthly temperatures range between 21–25 °C, and these cooler temperatures have made it a semi-temperate like area (Ojo, *et al.*, 2004).

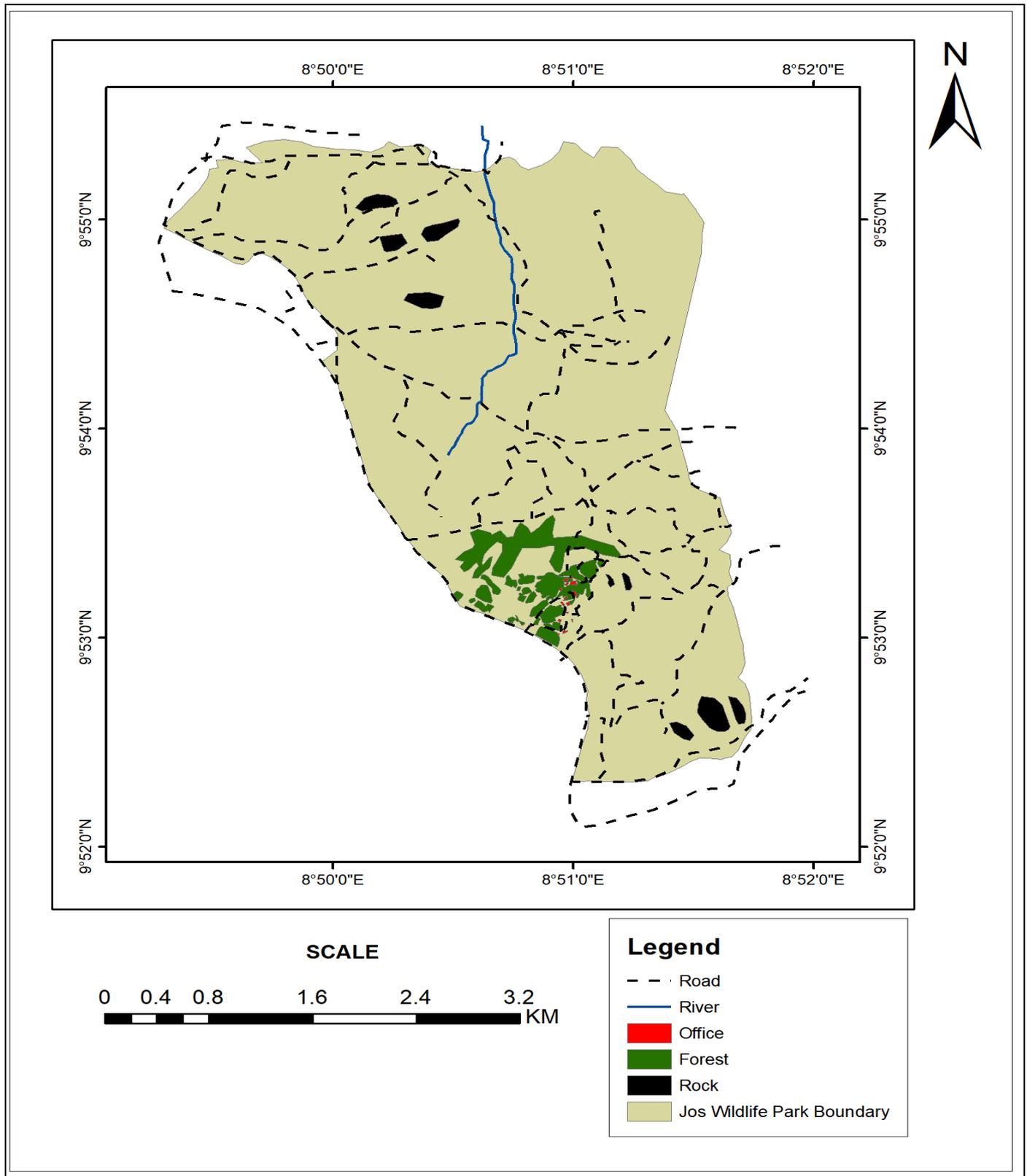


Fig 1 The map of Jos Wildlife Park

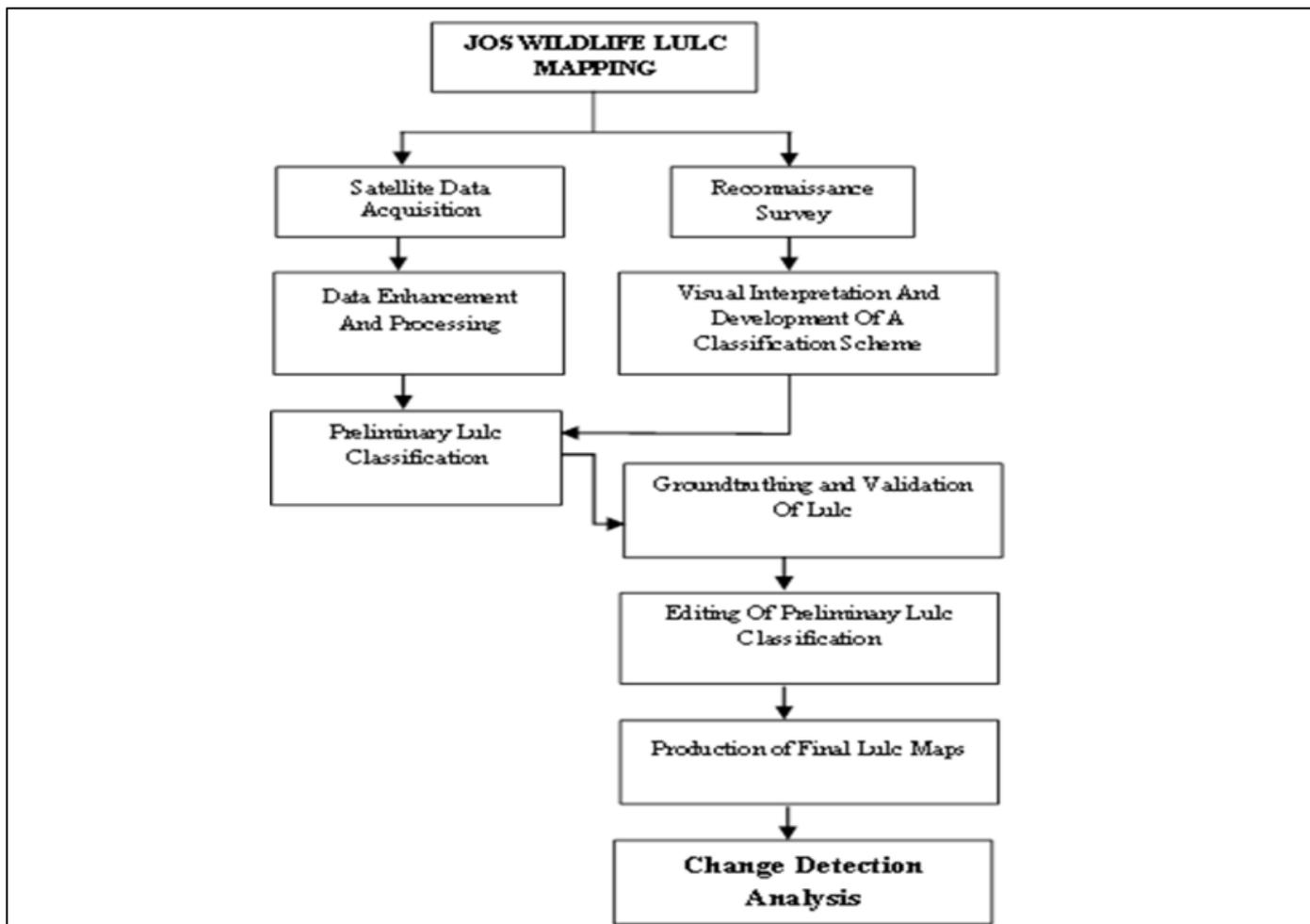


Fig 2 Flowchart of Steps for Jos Wildlife Park LULC Analysis

➤ *Data Acquired and Source*

Multispectral and multi-temporal LANDSAT satellite imageries of Jos Wildlife Park and surrounding settlement were acquired for five different years and they are as follows, 1988, 1998, 2008, 2018 and 2023. All the LANDSAT imageries were obtained from Global Land Cover Facility (GLCF) an Earth Science Data Interface. Landsat satellite imagery was used for land use and land cover classification of the Jos Wildlife Park; the Satellite data were pre-processed at the National centre for Remote Sensing Jos.

High resolution data and Global position system were used for field survey to mark the locations and identify the

different land use land covers types in the study areas, and confusing land cover features were validated using a high resolution images of the study areas.

A single scene of landsat TM, ETM+ and Landsat8 imageries has 30m x 30m spatial resolution, Resolution after rectification was captured by a sensor called Thematic Mapper, Enhance Thematic Mapper (ETM+) and Operational Land Imager/Thermal Infrared Sensor (OLI/TIRS). The satellites image bands were layer stacked and sub-mapped to get the imagery of the Jos Wildlife Park using GIS software (ARCGIS 10.8).

Table 1 Landsat Images Acquired for LULC Classification

S/N	Data Type	Date	Resolution	Source
1.	Landsat TM	16-02-1988	30m	GLCF
2.	Landsat TM	18-11-1998	30m	GLCF
3.	Landsat ETM <sup>+</sup>	11-04-2008	30m	GLCF
4.	Landsat 8 OLI/TIRS	10-02-2018	30m	GLCF
5.	Landsat 8 OLI/TIRS	07-01-2023	30m	GLCF

➤ *A Classification Scheme for the Study*

The classification scheme which gives a broad classification of the Land use Land cover of the study area is shown in Table 2.

Table 2 Classification scheme of the selected land cover types

S/N	CLASS	DESCRIPTION
1	Vegetation	Areas covered with different species of plants, shrubs and bushes
2	Built-Up	Any artificial infrastructure, residential buildings, commercial areas, industrial zones, roads around the park
3	Farm Land	Farm land includes most flat areas and also some steep slopes where various food crops are grown, either on a wet season or using irrigation
4	Bare Land	Bare land denotes areas that are without any vegetation cover at the time of satellite image acquisition
5	Rocky Outcrop	Rocky outcrop is a visible exposure of rocks in the study area.

#### ➤ Data Analyses

All satellite image analyses were carried out using ArcGis 10.8 software, at the National Centre for Remote Sensing Jos (NCRS). The digital remote sensing data (satellite images) was processed and geo referenced in ArcGis 10.8 software. The points recorded with GPS during field survey were imported into to ArcGis environment and the points were superimposed on the geo-referenced satellite images to aid in land use land cover classification of the Jos Wildlife Park. The geo-referenced images were studied for the land use land cover change analysis in the Arc view environment.

The satellite images were geometrically corrected and ground control point obtained through extensive ground survey and the use of high resolution imageries permitted the identification of conflicting features. The satellite imageries were made to pass through the processes of image enhancement, Geo-referencing, re-sampling, image classification and digitizing.

A supervised classification was performed on false color composites (bands 4, 3 and 2) into the following land use land cover classes; vegetation, built-up, farm land, bare land, rocky outcrop and water bodies. The enhanced satellite images were classified into different classes using ArcGis 10.8 and the classified images of different years 1988, 1998, 2008, 2018 and 2023 of Jos Wildlife and environs were compared after classification to see the level of changes in land use land cover at the Jos Wildlife Park over the years.

The information collected during the field survey (ground truthing was combined with the high resolution imageries were used to assess the accuracy of classification. All statistical analysis was carried out using Microsoft Excel. This was carried out to see the difference in land use land cover changes between the years (1988, 1998, 2008, 2018 and 2023). Also graphs showing the levels of changes in the land use land cover in the area were carried out using Microsoft excel. ArcGis 10.8 was used to generate the land use land cover maps of the Jos Wildlife Park.

#### IV. RESULTS AND DISCUSSION

The remote sensing and geographic information system (GIS) techniques were used to identify the land use land cover categories in Jos wildlife Park, as follows; vegetations, built-up, farm land bare land and rocky outcrop. The overall dynamics of land use land cover changes for the period of the study from 1988 to 2023 are given in table 2; table 3; and figure 3.

This study analyzed the decadal land use land cover changes in the study area and it was observed that vegetation, bare land and rocky out crop experience high declined in every 10 years (table 4) while built-up and farm land recorded an increase land cover size in every 10 years during the period of the study.

The result of the study for the period of 35 years, showed a massive reduction in the vegetation cover from 904.70 Ha in 1988 to 390.15Ha in 2023 and recorded a decreased of -514.55 Ha change in area size during the period of the study. An increase of 453.69 Ha areas from 84.96Ha to 538.65Ha was observed for built-up land cover in the study area from 1988 to 2023 respectively. Similarly, an increase of 184.61Ha in the farm land cover from 192.24Ha to 376.85Ha was observed in the study area from 1988 to 2023, this increase in the farm land and built-up land cover could be due to massive deforestation activities in Jos Wildlife Park and surrounding. It is observed, both the bare land and rocky outcrop experience decrease in the area cover, this could be due to high demand for fuel wood to meet the high population growth (table 2; figure 3).

The LULC maps of Jos Wildlife Park and environs for 1988, 1998, 2008 and 2023 are shown in figure 7 while the area covered by the various classes are shown in Table 2.

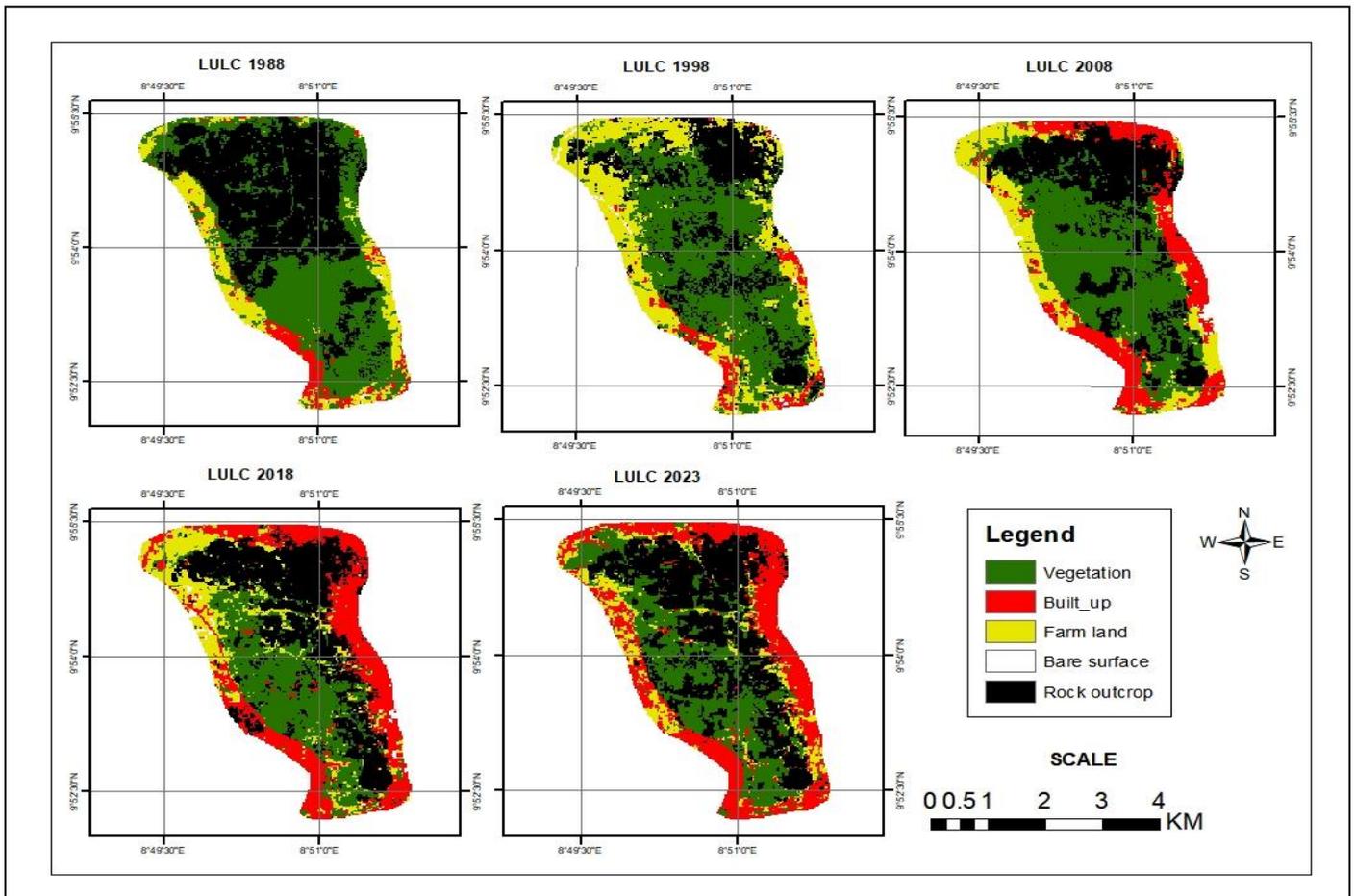


Fig 3 Land Use/Land Cover Maps of Jos Wildlife Park and Environs for the Year 1980, 1998, 2008 and 2023

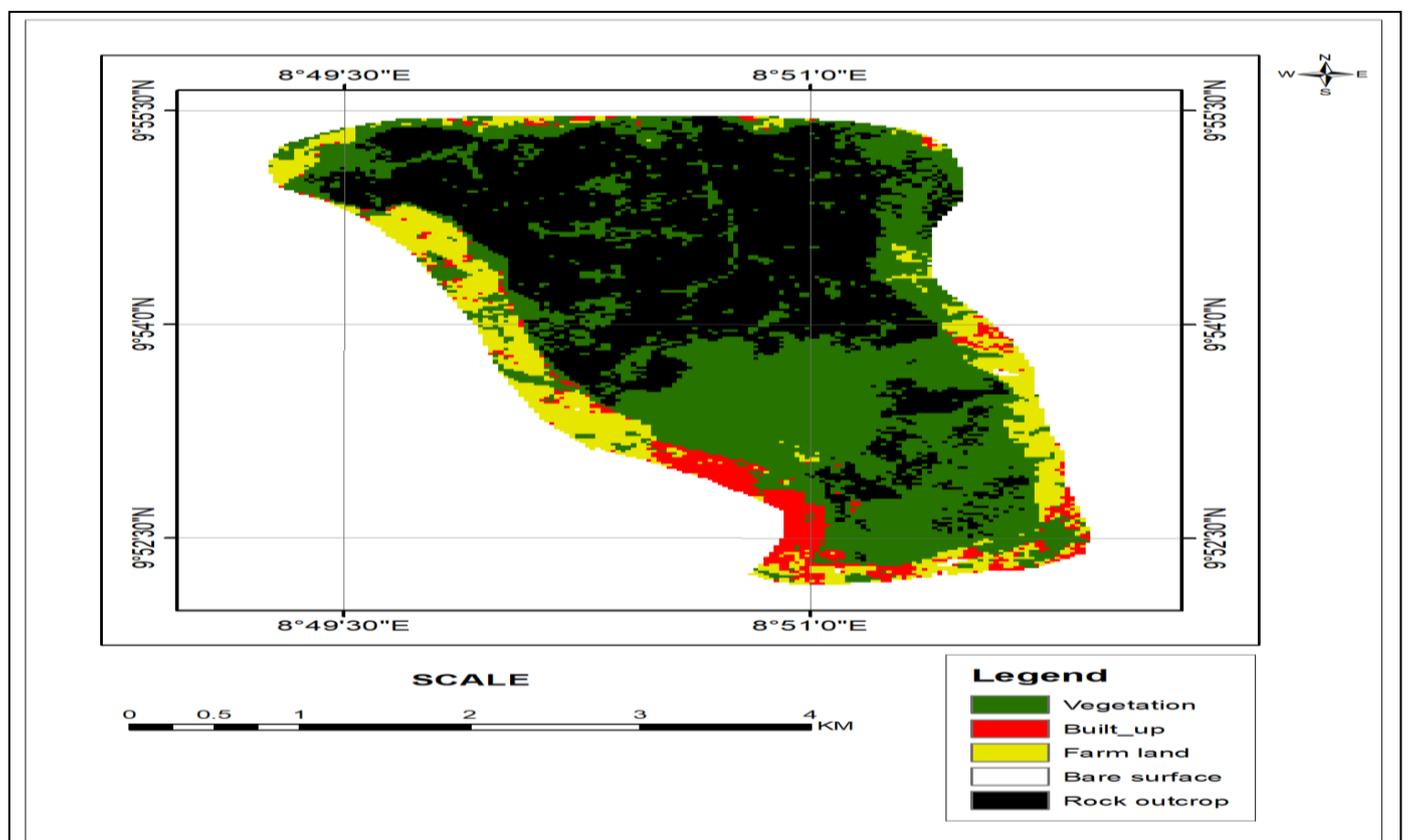


Fig 4 The Land Use Land Cover Map of Jos Wildlife Park, Year 1988

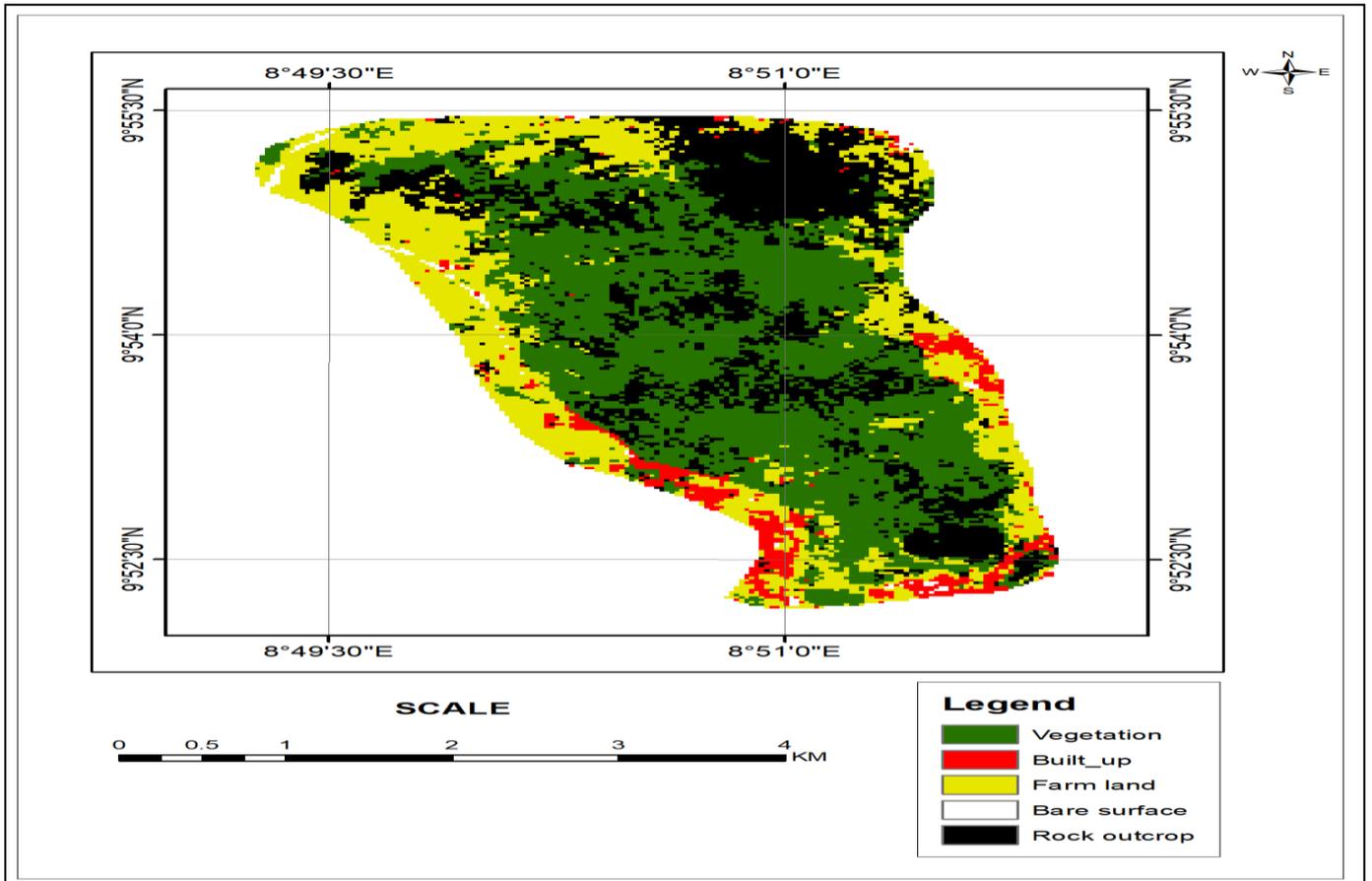


Fig 5 The Land Use Land Cover Map of Jos Wildlife Park, Year 1998

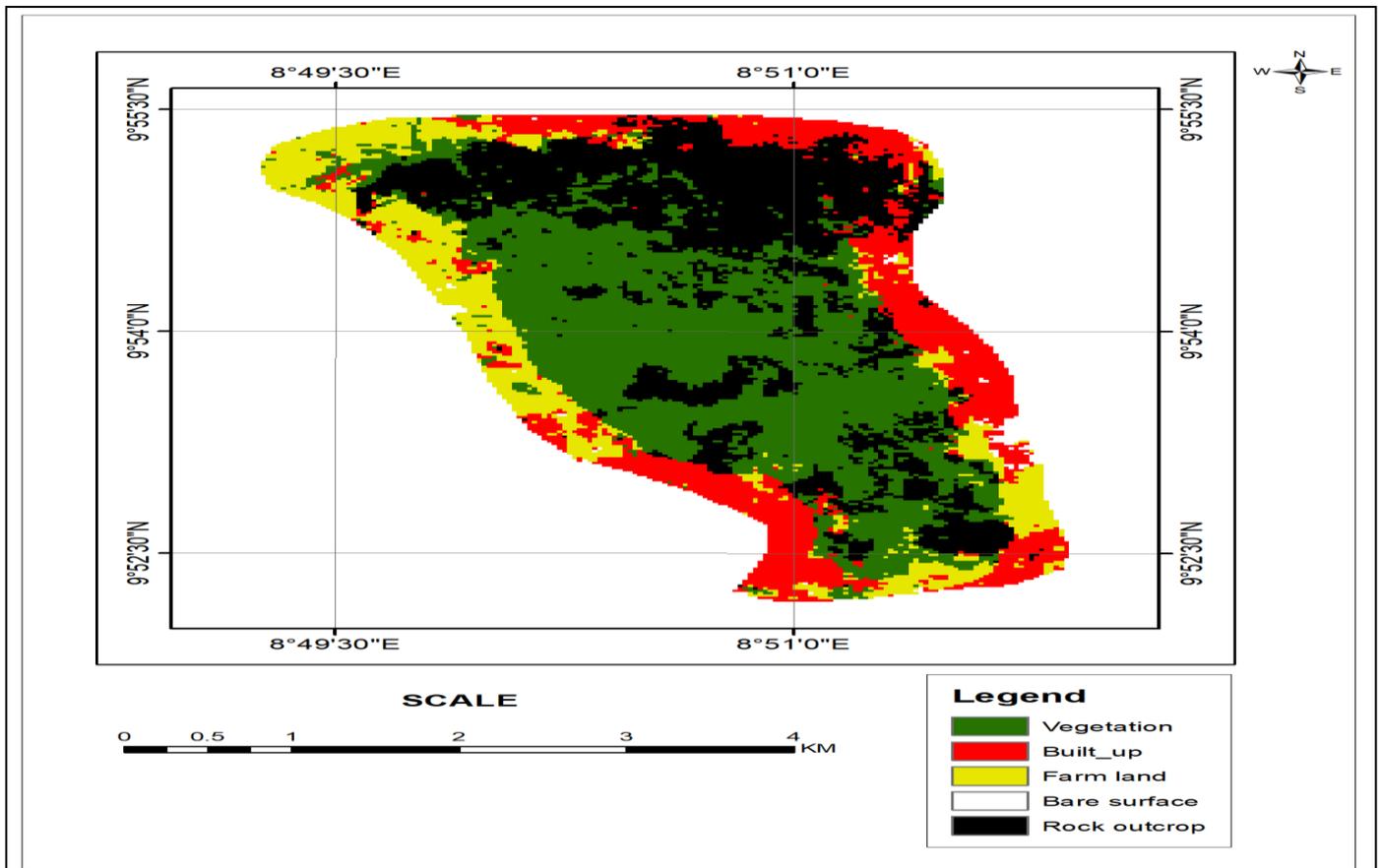


Fig 6 The Land Use Land Cover Map of Jos Wildlife Park, Year 2008

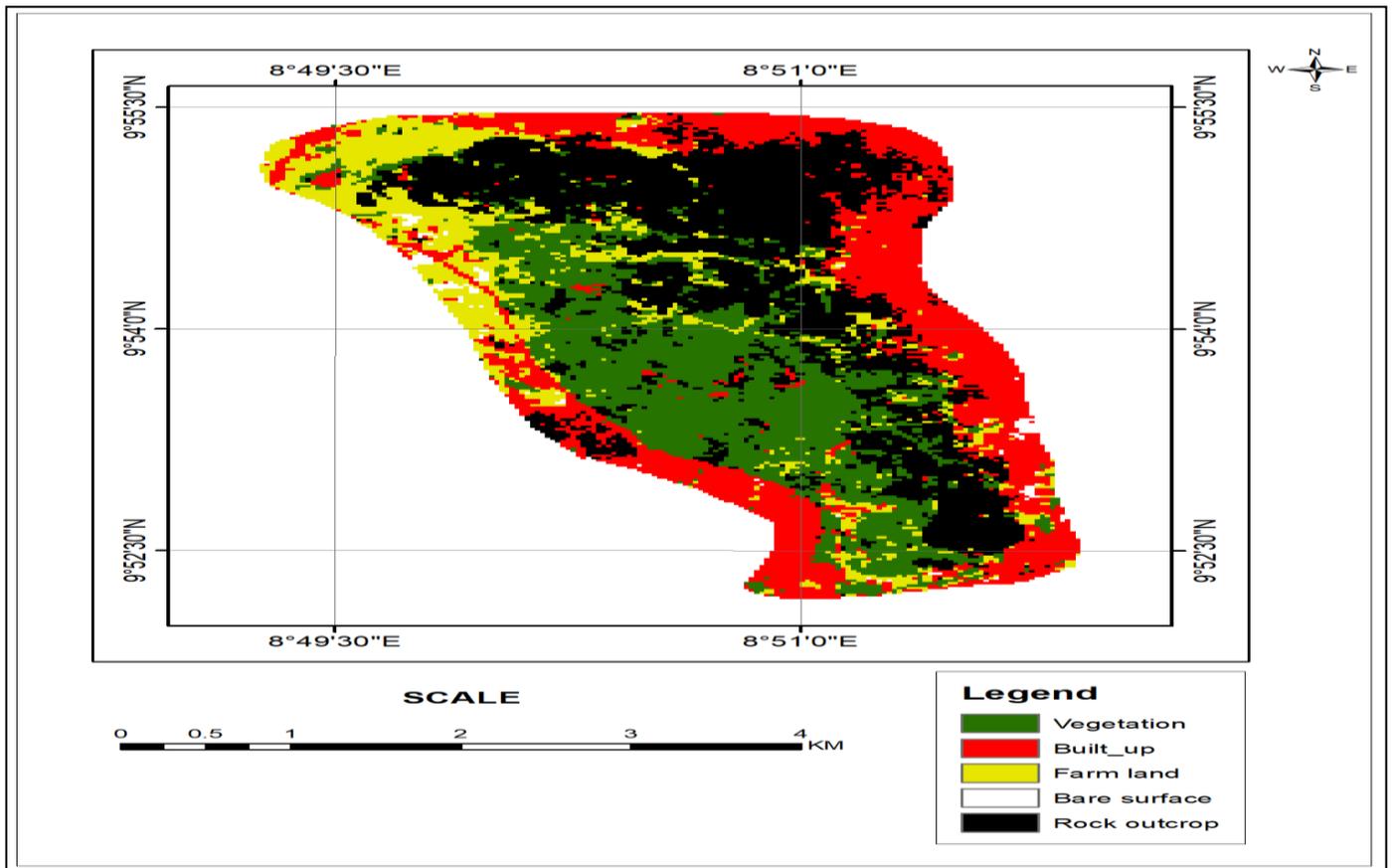


Fig 7 The Land Use Land Cover Map of Jos Wildlife Park, Year 2018

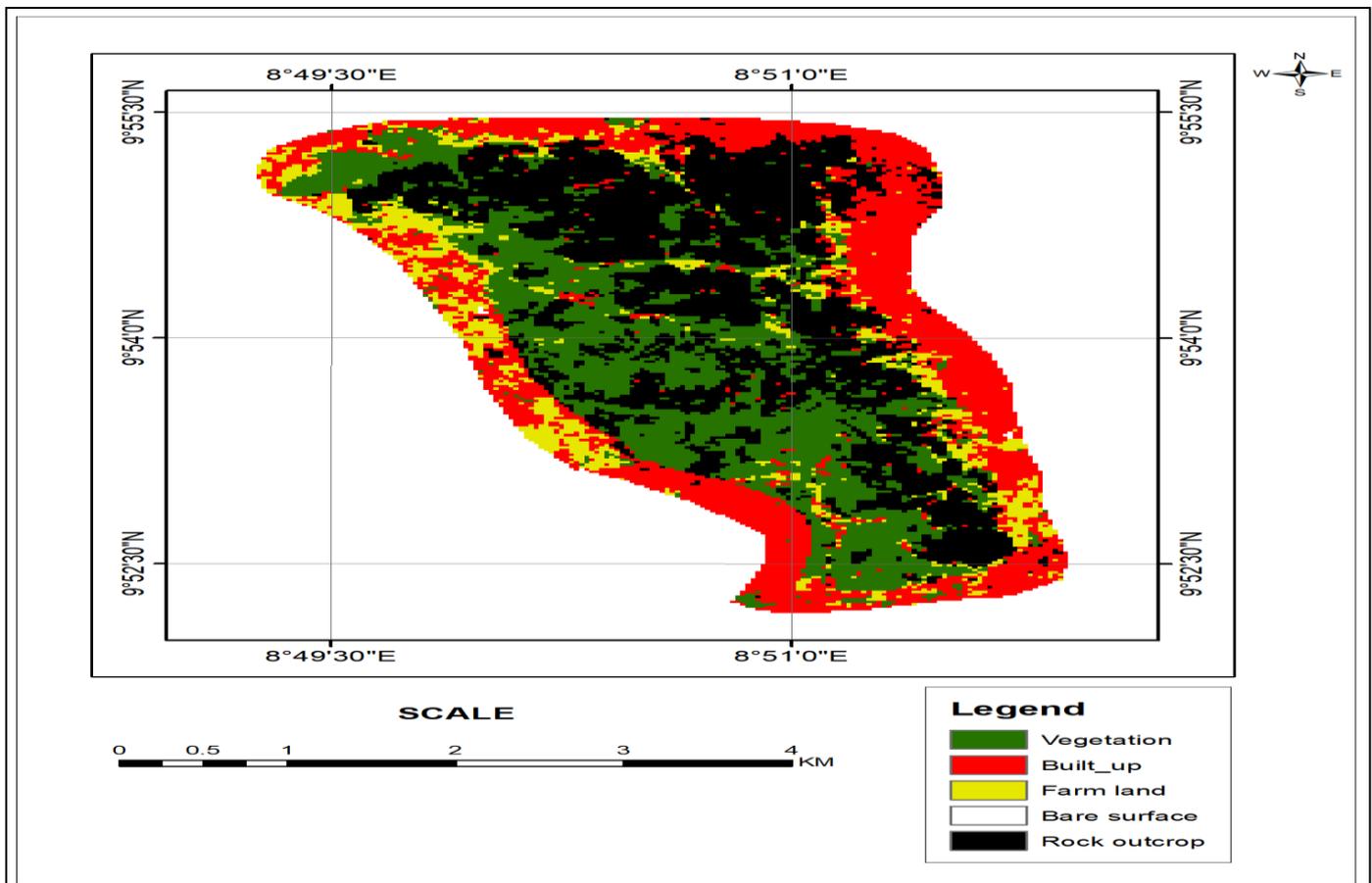


Fig 8 The Land Use Land Cover Map of Jos Wildlife Park, Year 2023

Table 2 Area Covered by Various Land Use Classes Around the Jos wildlife Park from 1988 to 2023

Land Use Class Name	1988 Area (Ha)	1988 Area (%)	1998 Area (Ha)	1998 Area (%)	2008 Area (Ha)	2008 Area (%)	2018 Area (Ha)	2018 Area (%)	2023 Area (Ha)	2023 Area (%)
Vegetation	904.70	52.51	743.22	43.14	661.14	38.38	458.91	26.64	390.15	22.65
Built-up	84.96	4.93	91.45	5.31	197.09	11.44	339.75	19.72	538.65	31.27
Farm land	192.24	11.16	431.64	25.05	446.69	25.93	534.53	31.03	376.85	21.87
Bare land	2.43	0.14	12.15	0.71	11.79	0.68	14.49	0.84	0.72	0.04
Rocky outcrop	538.45	31.25	444.32	25.79	406.07	23.57	375.10	21.77	416.41	24.17
Total	1722.78	100.00	1722.78	100.00	1722.78	100.00	1722.78	100.00	1722.78	100.00

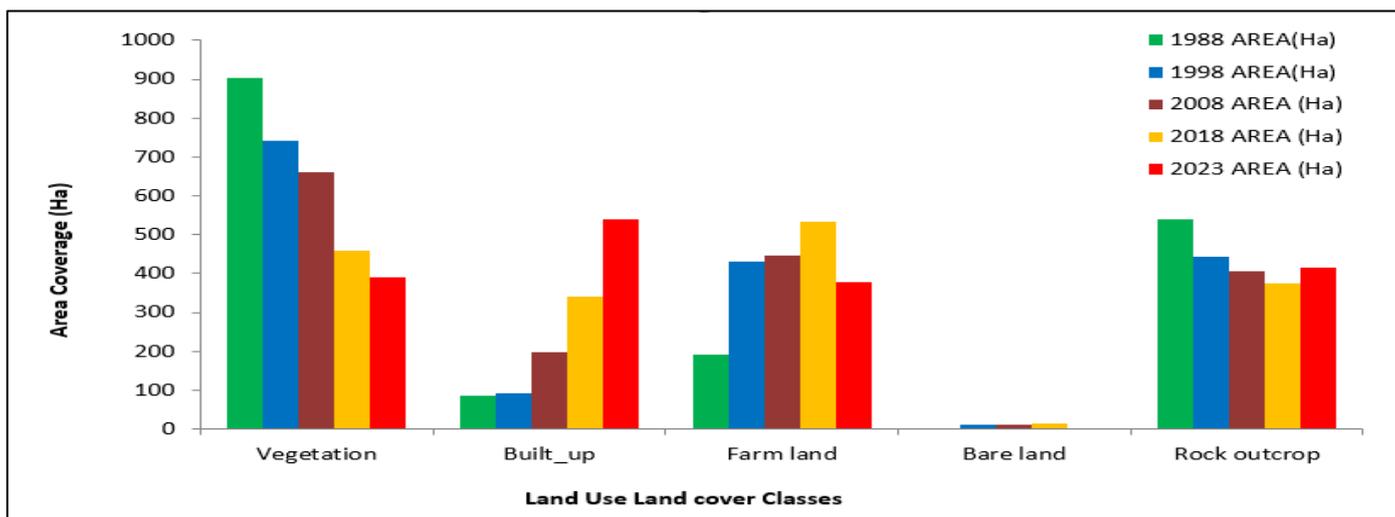


Fig 9 Area Covered by Various Land Use Classes Around the Jos wildlife Park from 1988 to 2023

Table 3 A Land Use Land Cover Changes Over 36 Years, from 1988 to 2023 in Jos Wildlife Park

Class Name	1988 Area (Ha)	2023 Area (Ha)	Change	% Change	Inference
Vegetation	904.7	390.15	-514.55	-40.31	Decreased
Built-Up	84.96	538.65	453.69	35.54	Increased
Farm Land	192.24	376.85	184.61	14.46	Increased
Bare Land	2.43	0.72	-1.71	-0.13	Decreased
Rocky Outcrop	538.45	416.41	-122.04	-9.56	Decreased
Total	1722.78	1722.78	0.00	0.00	

Table 4 Decadal Land Use Land Cover Changes of Jos Wildlife Park from 1988 to 1998, 1998-2008, 2008-2018, and 2018-2023

Land Use Class Name	Changed Area (1998-1988)	Changed Area (2008-1998)	Changed Area (2018-2008)	Changed Area (2023-2018)
Vegetation	-161.48	-82.08	-202.23	-68.76
Built-up	+6.49	+105.64	+142.66	+108.9
Farm Land	+239.4	+15.05	+87.84	+132.32
Bare Land	+9.72	-0.36	+2.7	-13.77
Rocky Outcrop	-94.13	-38.25	-30.97	-158.69

Note: (+) sign denotes increase and (-) sign denotes decrease of magnitude of change of land use classes from 1988 to 2023.

➤ Error Matrix and Accuracy Assessment

Accuracy assessment of land use land cover classification is an important process that must be carried out for the data to be useful in change detection; it is also, an important criterion that influences the acceptability of the classification (Rosenfield, 1986). The results from the image classification were compared with the reference information from the field data using confusion or an error matrix in ArcGis 10.8 software. The results of the accuracy assessment for the five different time frames (1988, 1998, 2008, 2018 and 2023) are shown in table 6, 7, 8, 9 and 10 respectively. The

highest accuracy was identified in 2018 supervised classification (95.625% accuracy) while the lowest accuracy was found in 2023 supervised classification (83.75% accuracy). From the result and the level of classification assessment showed that supervised image classification is a better alternative for multi-temporal land use land cover change detection. The overall accuracy assessment for 1988, 1998, 2008, 2018 and 2023 was good enough to be used by researchers and decision makers detect changing scenarios in Jos Wildlife Park.

Table 5 Algorithms for Accuracy Assessment Used in this Research Work

Overall Accuracy	$\frac{\text{Total number of correctly classified pixels (diagonal)}}{\text{Total number of reference pixel}} \times 100$
User Accuracy	$\frac{\text{Number of correctly classified pixels in each category}}{\text{Total number of classified pixel in that category (row total)}} \times 100$
Producer Accuracy	$\frac{\text{Number of correctly classified pixels in each category}}{\text{Total number of reference pixels in that category (column total)}} \times 100$

Table 6 Accuracy Assessment of Land Cover Classification, Using Error Matrix of the Most Accurately Classified Satellite Image of Jos Wildlife Park for the 1988

Reference Data/Classified Data	Vegetation	Built-up	Farm Land	Bare Land	Rocky Outcrop	Classified Total
Vegetation	43	3	4	2	0	52
Built-up	2	26	0	0	2	30
Farm land	3	0	36	0	0	39
Bare land	2	1	0	8	4	15
Rocky outcrop	0	0	0	0	24	24
Reference Total	50	30	40	10	30	160

Total Truth Values	137
Total Sampled Points	160
Total Wrongly Predicted	23
Overall Accuracy	85.625%

Table 7 Accuracy Assessment of Land Cover Classification, Using Error Matrix of the Most Accurately Classified Satellite Image of Jos Wildlife Park for the 1998

Reference Data/Classified Data	Vegetation	Built-up	Farm Land	Bare Land	Rocky Outcrop	Classified Total
Vegetation	46	0	1	0	0	47
Built-Up	0	27	2	1	0	30
Farm Land	3	2	37	0	0	42
Bare Land	0	0	0	9	0	9
Rocky Outcrop	1	1	0	0	30	32
Reference Total	50	30	40	10	30	160

Total Truth Values	149
Total Sampled Points	160
Total Wrongly Predicted	11
Overall Accuracy	93.125%

Table 8 Accuracy Assessment of Land Cover Classification, Using Error Matrix of the Most Accurately Classified Satellite Image of Jos Wildlife Park for the 2008

Reference Data/Classified Data	Vegetation	Built-up	Farm Land	Bare Land	Rocky Outcrop	Classified Total
Vegetation	40	1	0	0	0	41
Built-up	0	27	1	0	0	28
Farm Land	7	2	35	0	0	44
Bare Land	0	0	1	10	0	11
Rocky Outcrop	3	0	0	0	30	33
Reference Total	50	30	37	10	30	157

Total Truth Values	142
Total Sampled Points	160
Total Wrongly Predicted	18
Overall Accuracy	89.121%

Table 9 Accuracy Assessment of Land Cover Classification, Using Error Matrix of the Most Accurately Classified Satellite Image of Jos Wildlife Park for the 2018

Reference Data/Classified Data	Vegetation	Built-up	Farm Land	Bare Land	Rocky Outcrop	Classified Total
Vegetation	50	0	1	0	0	51
Built-up	0	30	3	1	0	34
Farm Land	0	0	36	1	0	37
Bare Land	0	0	0	8	1	9
Rocky Outcrop	0	0	0	0	29	29
Reference Total	50	30	40	10	30	160

Total Truth Values	153
Total Sampled Points	160
Total Wrongly Predicted	7
Overall Accuracy	95.625%

Table 10 Accuracy Assessment of Land Cover Classification, Using Error Matrix of the Most Accurately Classified Satellite Image of Jos Wildlife Park for the 2023

Reference Data/Classified Data	Vegetation	Built-up	Farm Land	Bare Land	Rocky Outcrop	Classified Total
Vegetation	40	0	9	0	2	51
Built-up	0	29	0	2	0	31
Farm Land	10	1	30	1	0	42
Bare Land	0	0	0	7	0	7
Rocky Outcrop	0	0	1	0	28	29
Reference Total	50	30	40	10	30	160

Total Truth Values	134
Total Sampled Points	160
Total Wrongly Predicted	26
Overall Accuracy	83.75%

**V. CONCLUSIONS**

This is aimed at assessing the effect of urbanization on the Jos Wildlife Park using the methods of remote sensing and geographic information system. To understand the trends and pattern of urbanization and its impact on the Jos Wildlife Park, an analysis of the land use land cover change classification was carried out for the study area. From the result of the study, a significant changes, especially in the vegetation cover, built-up, farm land, bare land and rocky outcrop was recorded and this is also, reported by the research of Wang, *et al.*, (2020). In this study, land use land cover changes were identified in the Jos wildlife Park, using the techniques of GIS and remote sensing data. The findings from the study showed an increase in built-up and farm land areas from 1988 to 2023. There was a massive decreased in vegetation land cover area during the period of study.

The expansion of farm land and built-up area in the study could be due to high rate in human population growth around the Jos Wildlife Park. In order to meet the demand of growing population, the rate of deforestation increased in the park over the 35 years. The destruction of the vegetation cover in Jos Wildlife Park, has poised a negative impact on the animals and their habitats. Best on the result of this study there is need to improve protection and conservation management in and around the Jos wildlife Park. There is also, need for awareness to the people living around the Jos wildlife Park on the importance of protecting and conserving the park.

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