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ASSESSMENT OF 30 YEARS LAND USE AND LAND COVER CHANGES OF DOMA NASARAWA STATE

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ABSTRACT
This study aimed at using remote sensing in assessing and identifying the land use and land cover change in Doma Local Government Area (LGA) of Nasarawa within the period of 30 years. The Landsat images, Landsat 8 OLI/TIRS and 4-5 TM, within an interval of 30 years from 1991 to 2023, were used to identify the land use. Supervised classification techniques and five broad classifications were used to classify land use changes. In 1991, dense forest (64888.66 ha) and moderate forest (99960.03 ha) dominated the land use. In 2023, the dense forest was completely lost, while the moderate forest was reduced significantly to 85903.38 ha (33.13 %). This represents significant negative changes in dense forest (-100 %) and moderate forest (-14.06 %). Change in area between the study periods shows a significant increase in built-up areas (9.83 %) and open land (643.9 %). This shows that the land use change was mainly driven by urbanisation, coupled with the resultant increased rate of land conversion for agriculture. Accuracy assessment for LULC classification for 1991 shows an overall accuracy of 86.30 % while that of 2023 was 73.40 %. This study indicates a significant loss of vegetation cover within this period, leading to the decimation of vegetation and calls for aggressive reforestation and urgent conservation practices to prevent continuous vegetation loss in Doma LGA.

Keywords: Accuracy assessment, Classification, Forests, Land use change, Remote sensing

INTRODUCTION
Land is the stage on which all human activity is being conducted and the source of the materials needed for this conduct (Briassoulis, 2020). Human use of land resources gives rise to “Land Use” which varies with the purposes it serves, for example, food production, provision of shelter, recreation, extraction and processing of materials, etc. Land use is shaped under the influence of two broad sets of forces; they are human needs and the environmental features and process, neither one of these forces stays still; they are in a constant state of flux as change is the quintessence of life (Arome, 2012).

Land which is the ultimate resource of the biosphere refers to a specific area of the earth surface with physical entity encompassing its topography and spatial nature. It is one of the characteristics of space that is significant for planning and management purposes. Land cover refers to the physical cover on the land including both the natural and modified vegetation and artificial constructions. Land use describes the use of the land by the people usually with emphasis on the functional role of land in economic activities and man’s activities which are directly related to the land (Abbas, 2012).

Change in the uses of land occurring at various spatial levels within various time periods are the material expressions, among others of the environmental and human dynamics and their interactions which are mediated by land (Briassoulis, 2020). In every settlement, there is always a peculiar internal organization of land uses; this organization is simply the structure of land use. In the urban area the internal organization is a reflection of different requirements of the various economic activities and classes of residence (Arome, 2012). The land use patterns in an urban area at any particular time therefore represent the cumulative effects of a myriad of decision and actions by various individuals and organizations. Land use changes cause a number of environmental impacts in urban, suburban, rural and open space areas. Notable are the land use changes (land conversion) that occur in the periphery of large urban concentrations that are subject to urbanization and industrialization pressures and frequently result in losses of prime agricultural lands and tree cover (Arome, 2012). The socio-economic impacts of land use/cover change at local levels revolve around such issues as availability of land for food production, changes (reduction) in land productivity and, consequently, (lower) profitability and changes in industrial structure, employment/unemployment, poverty, population change and migration, and quality of life issues such as health and amenity. However, these concerns are restricted to the particular localities where these changes occur. A typical example is the issue of farmland conversion to urban and other uses. Local level socio-economic impacts, like environmental impacts, may act cumulatively and cause larger than local impacts in the longer term (Briassoulis, 2020).

Remote sensing has been increasingly contributing to timely, accurate, and cost-effective assessment of biodiversity-related characteristics and functions during the past years. Methods cover a wide range of fields, including: habitat extent and condition monitoring; species distribution; pressures from unsustainable management, pollution and climate change; ecosystem service monitoring; and conservation status assessment of protected areas.Satellite data are considered as the only realistic means to monitor deforestation and forest degradation at a timely manner (Lynch *et al*., 2013). Data time series are necessary to detect deforestation. Landsat data have been primarily used in monitoring forest disturbance (Petrou *et al*., 2015). The advantages of using remote sensing techniques include data consistency, wide coverage, maximum data precision and accuracy. Remote sensing can classify land use features of an area based on their distinguish characteristics which can then be used for making specific land-use and land cover maps of the areas (Akomolafe and Rahmad, 2020).

The forest vegetation in Doma LGA in Nasarawa State is severely threatened by an increased use of firewood and cutting down of trees for agricultural purposes (Mustafa et al., 2025). Other land use practices have also contributed greatly to the increasing emission of CO_2 due to the population growth in Doma LGA. Therefore, there is need for a detailed assessment of the historical and current changes in the land use and land cover of this LGA to enhance the formulation of appropriate conservation plans that would mitigate the effect of climate change, hence this study.

MATERIALS AND METHODS

Study Area

The study was conducted in Doma Local Government Area of Nasarawa State of Nigeria. The study area lies between latitude 8° 29' – 8° 30' North and longitude 8° 29' – 8° 30' East. Doma local government has an area of 2,714 km^2 as shown in Figure 1. Doma has an estimated population of 300,607. Agriculture and mining constitute the major dominant economic activities (Nuhu & Ahmed, 2013).

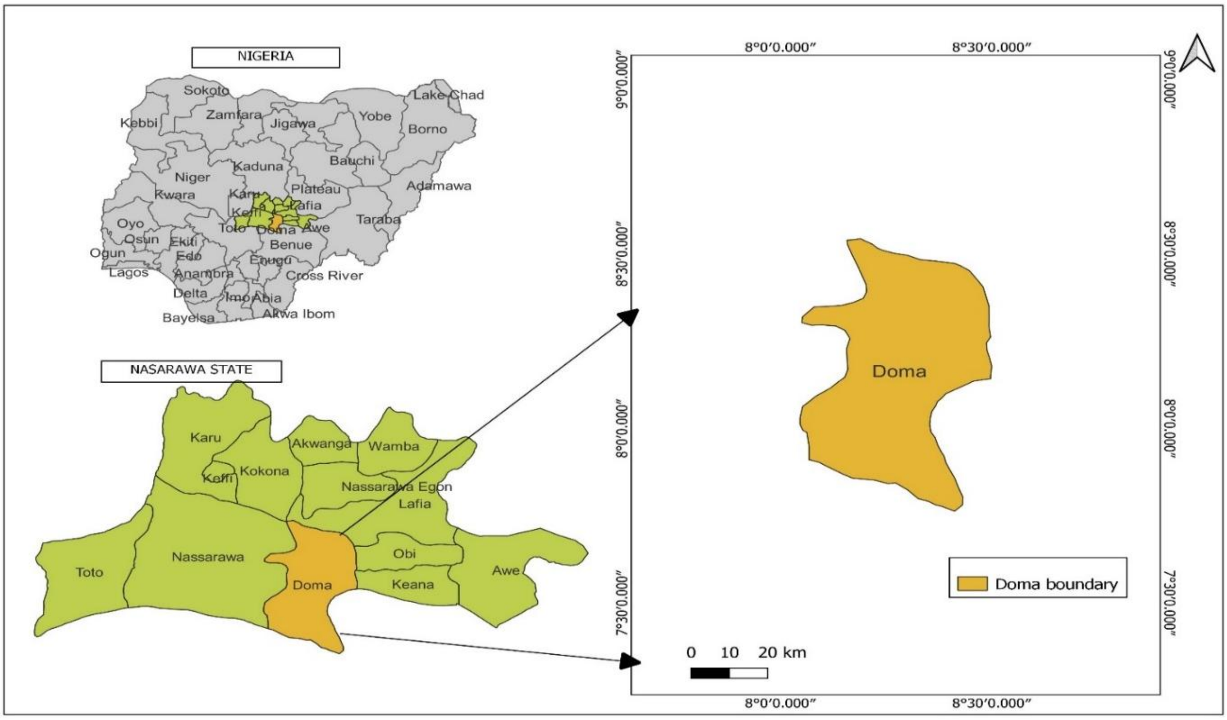

Figure 1: Study area map of Doma LGA, Nasarawa State, Nigeria

Land Use and Land Cover Changes of Doma (LULC)

Spatial data acquisition

In order for the assessment LULC of the catchment area between the period of 1991 to 2023, Landsat satellite images were gotten from the website of United State Geological Survey as shown in Table 1. The Landsat images include the Landsat 8 OLI/TIRS (operational land imager/thermal infrared sensor), Landsat 4-5 TM (thematic mapper) (Akomolafe and Rahmad, 2020).

Geo-referencing techniques

The acquired Landsat raster files were loaded into the" QGIS 3.22.1'software for further geo-referencing and analysis. The images were subjected to techniques including data pre-screening, enhancement of the images by cloud removal, correction of radiometric errors, mosaic and clipping of the images and image classification (Akomolafe & Rahmad 2020).

Table 1: Characteristics of the satellite images used

Satellite features	1991	2023
Sensors	Landsat 4-5 TM+	Landsat 8 OLI/TIRS
Path/row	188/054	186/055
Spatial Resolution	30 m	30 m
Date of acquisition	07/01/1991	25/12/2023
Number of bands	7	11

Table 2: Description of LULC classes of Doma town

LULC class	Description
Dense Forest	Forest with tree canopy density above 70 %
Moderate Forest	Forest with tree canopy density between 40 and 70 %
Built-Up and Human Settlement	Urban Areas, Rural Areas, Farmhouses
Wetlands	Natural and Artificial ponds/lakes
Open Land	Area with very low or no vegetation, rocky outcrops, barren land, abandoned land

Image Classification

The satellite image classification involved both unsupervised random selection of sample training points and supervised classifications of the LULC types presents five different classes as seen as seen in Table 2.

Classification Accuracy Assessment

The accuracy of the classification was assessed the ideal method of taking ground truth data of the land cover of Doma with the aid of a Garmin Etrex 10 device (Akomolafe & Rahmad, 2020). These ground truth data (GPS coordinates) were compared with the already classified LULC maps as shown in Table 2.

The determination of the rate and extent of change in the LULC of Doma within the studied periods was carried out using the following equations i, ii and iii.

Changed area (C a) = T a (2^{nd} year) – T a (1^{st} year)..…(i)

Changed extent (C e) = C a / Ta (1^{st} year) ……... (ii)

Percentage of change = C e x 100 …………...... (iii)

Where (Ta) = total area

RESULTS AND DISCUSSION

Land Use and Land Cover Changes of Doma Town

The satellite images projected as maps for both unsupervised random selection of sample training points and supervised classifications, shows LULC map of Doma in 1991 with significant coverage for dense and moderate forests. Built up areas also showed significant level of coverage, while open land and wet land recorded reduced level of coverage (Figure 2). LULC map of Doma in 2023 as seen in Figure 3 shows no coverage observed for dense forest and significant decrease in coverage for moderate forests. Significant increase was observed for open land wetlands and built up areas.

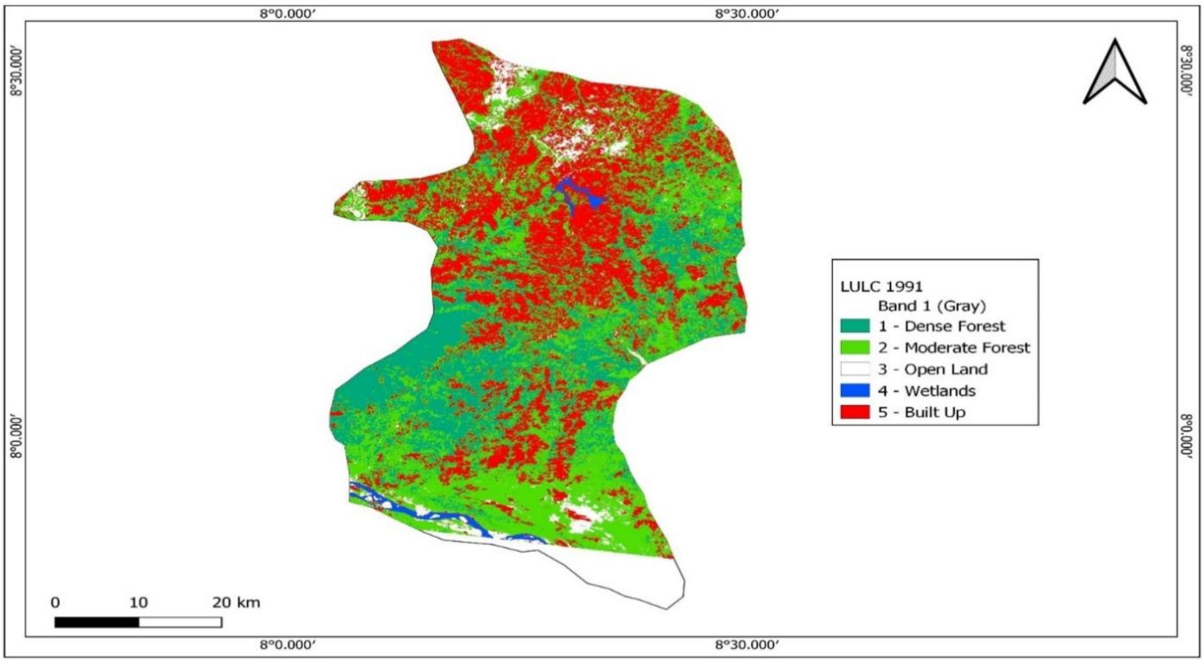

Figure 2: Land use and land cover map of Doma town in 1991

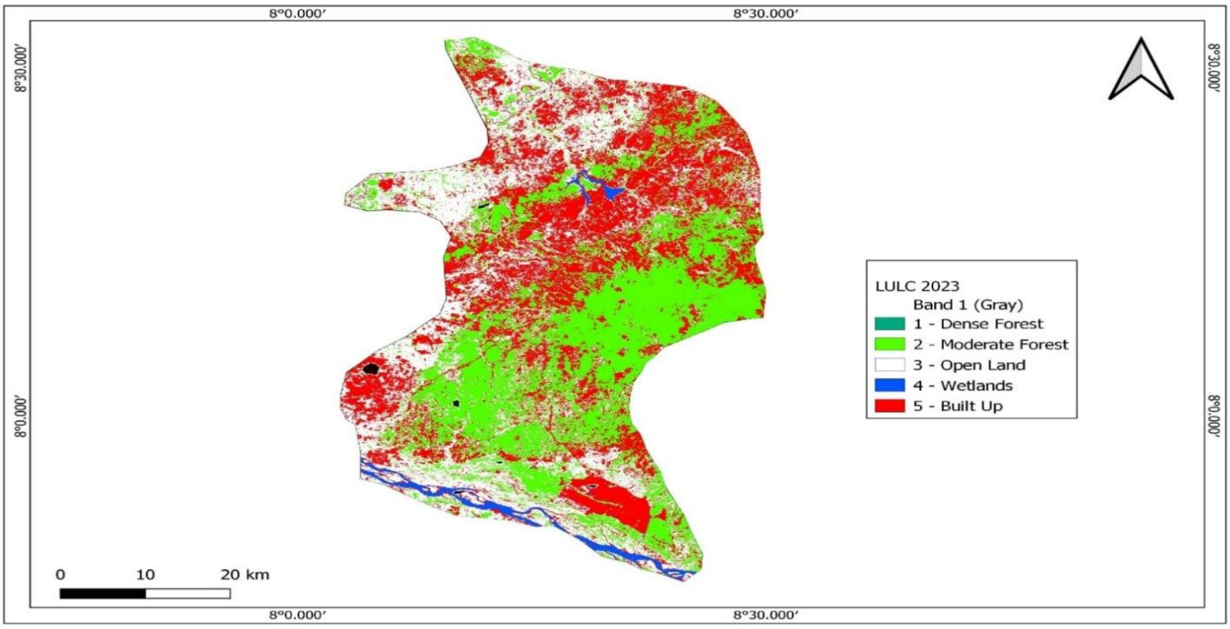

Figure 3: Land use and land cover map of Doma town in 2023

Table 3: Areas of land occupied by each LULC class

LULC Class	1991		2023		1991-2023	
	Area (ha)	Area (%)	Area (ha)	Area (%)	Change in area (ha)	Change in area (%)
Dense Forest	64888.66	26.09	0	0	-64888.66	-100
Moderate Forest	99960.03	40.19	85903.38	33.13	-14056.65	-14.06
Open Land	10748.61	4.32	79961.58	30.84	69212.97	643.9
Wetlands	2498.31	1.00	4255.74	1.64	1757.43	70.34
Built Up	81176.49	32.6	89151.39	34.38	7974.9	9.83
Total area (ha)	**248,675.40**		**259,272.1**			

Area of land occupied by the LULC classes

The LULC classification shows significant decrease in area covered by dense forest (64888.66 ha) and moderate forest (99960.03 ha) in 1991 compared to dense forest (0 ha) and moderate forest (85903.38 ha) in 2023. Significant increase was recorded in open lands, wetland, and built up areas from 10748.61, 2498.31, 81176.49 ha in 1991 to 79961.58, 4255.74, 89151.39 ha respectively in 2023 (Table 3).

Similar result was obtained by Akomolafe and Rahmad (2020) where the built-up area dominated the land-use of Lafia, Nigeria with an area of 144645 ha (52.21 %) while the wetland stillremained the least with area of 1477 ha. Akomolafe and Rahmad (2020) attributed these changes to geometric increase in the urbanization of this city, with consistent loss of the forests from 1985 to 2020 with an annual rate of loss of 0.46 %.

Percentage change in area calculated shows significant negative change in dense forest with -100 % change and moderate forest with -14.06 % change area while open lands, wetlands, and built-up area showed significant increase in percentage change in area with, 643.9 %, 70.34 and 9.83 % change in area as seen in Table 3.

Abbas (2012) observed built up of Niger Delta area had increased in 2008 to 7934.11 ha (2.18 %) due to massive construction works while the wetlands area decreased to 14562.16 ha (4.0 %) with specific classes of marsh being 3010.17 ha (0.83 %) and mangrove being 11551.99 ha (3.17 %) and concluded that there was a high rate of land use-land cover change leading to decimation of vegetation, sources of livelihood and resettlement of the people.

Classification Accuracy Assessment

Accuracy assessment for LULC classification for 1991 (Table 4) shows high values in all LULC classification for producer accuracy, ranging from 73.30 % in dense forests to 100 % in wetlands. User accuracy recorded 70.09 % in wetlands and 99.98 % in dense forest. Kappa coefficient was observed to have excellent agreement in all LULC classification, with high values of 0.99 in dense forest and 0.67 in moderate forests. Over all accuracy, a measure of proportion of reference site mapped correctly recorded a value of 86.30 %.

Table 4: Accuracy assessment showing the Kappa coefficient, producer, user, and overall accuracy for 1991 LULC classification

LULC class	Producer's accuracy	User's accuracy	Kappa coefficient	Overall Accuracy (%)
Dense Forest	73.30	99.98	0.99	86.30
Moderate Forest	76.41	88.20	0.67	
Open Land	98.91	70.09	0.68	
Wetlands	100.00	77.90	0.74	
Built Up	81.20	91.67	0.79	

Table 5: Accuracy assessment showing the Kappa coefficient, producer, user, and overall accuracy for 2023 LULC classification

LULC class	Producer's accuracy	User's accuracy	Kappa coefficient	Overall Accuracy (%)
Dense Forest	0	0	0	73.40
Moderate Forest	77.63	99.98	0.99	
Open Land	99.99	78.32	0.74	
Wetlands	79.00	83.7	0.61	
Built Up	74.10	41.60	0.53	

Accuracy assessment for LULC classification for 2023 (Table 5), shows high values for producer accuracy, ranging from 74.10 % in moderate forests to 99.99 % in open lands. User accuracy recorded 41.60 % in built up areas and 99.98 % in moderate forest. Kappa coefficient was observed to have excellent agreement with high values of 0.99 in moderate forest and 0.53 in built up areas. No accuracy assessment was recorded for dense forest in 2023. Over all accuracy recorded a value of 73.40 %

Kappa values greater than 80 % indicate strong classification performance, Kappa values between 40 and 80 % indicate good classification performance and Kappa values of less than 40 % indicate poor classification performance (Ubaekwe *et al*., 2021). The accuracy assessment for LULC classification for Doma indicates very good classification performance in this study.

CONCLUSION

Climate change and land use change interact to impact biodiversity through a wide range of mechanisms. Understanding these interactions will be necessary and very critical in decision making by policy makers particularly as it reveals the rapid loss of forest lands and whereas built up areas and open lands have increased. The increase in the built-up areas could be directly linked with increase in human population and its associated demand for resources. While the rapid increase in open land may be as a result of conversion of land for agricultural as it is one of the major economic activities alongside mining and timber production in Doma LGA. This forecasts serious implication for increase in greenhouse gases in the environment, loss of vegetation cover and biodiversity. It is therefore highly imperative for relevant government agencies to prioritize the conservation of the remaining forested areas in Doma Lafia, Nigeria.

Conflict of interest: The authors declare no conflicts of interest.

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