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EFFECT OF LAND USE AND LAND COVER CHANGE ON KURMIN DAWAKI FOREST RESERVE, ZANGON KATAF LOCAL GOVERNMENT AREA, KADUNA STATE, NIGERIA

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ABSTRACT

Forest degradation as a result of land use and land cover change constitute the major source of pressure on forest conservation and existence of forest estates. Today degradation of forest in recent times is not limited to natural forests as Land use and Land cover change are gradually getting into forest reserves and plantation. This calls for constant monitoring of LULC changes in our forest both natural, reserves and plantations. This study was carried out to assess LULC changes in Kurmin Dawaki Forest Reserve in order to promote sustainable management of the reserve. Data from this study was acquired from pre-existing satellite imagerie. Landsat 5 TM for 1997, Landsat 7 ETM+ for 2007 and Landsat 8 OLI for 2017 were down loaded from the United State Geological Survey website. Idrisi Terrset was used to perform a supervised maximum likelihood classification of the imagery. The result of the classification revealed three classes of Agricultural land, Grassland/Herbaceous Cover and Forest plantation. The percentage of land use and land cover (LULC) in Kurmin Dawaki forest preserve indicated that Agricultural land increased from 4.73% in 1997 to 5.27% in 2017. Grassland/Herbaceous Cover also increase from 10.43% in 1997 to 25.63% in 2017. The forest area decreased from 84.842% in 1997 to 57.93% in 2017. The magnitude of LULC change within 20 years period showed that 1.323 ha of the forest area was lost to other forms of land uses, Grassland/Herbaceous Cover increased by 1.26 ha within that period, Farm land also increased by 0.04 ha. It was established that LULC changes were going on in the Kurmin Dawaki forest preserve. Control of farming activities within the Reserve should be discouraged and reforestation of the Reserve was recommended.

Keywords: Degradation, farming, Grassland/Herbaceous, Survival, Forest Plantation,

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INTRODUCTION

The widespread loss and degradation of natural forests is now acknowledged as a major environmental issue, (Spilsbury, 2010). This degradation of the forest is not only limited to natural forest as land use and land cover change are gradually getting into forest reserves and plantations. During the first decade of the twenty-first century, global forest area declined by around 13 million ha yr−1 (FAO, 2010). However, such estimates based on national statistics are uncertain, Grainger (2008) report a substantially higher annual forest loss of approximately 20 million ha yr−1 for 2000–2005, based on analysis of satellite imagery. The Food and Agriculture Organization (FAO 2010) also report that during the decade 2000–2010, the area of undisturbed primary forest declined by an estimated 4.2 million ha yr−1 (or 0.4% annually), and largely due to agricultural expansion, urbanization, logging and other forms of human disturbance (FAO, 2016; Jande *et al.*, 2018; Ikyaagba *et al.*, 2020). Accurate data on the extent of forest degradation at the global scale are difficult to obtain (Gibbs *et al.*, 2007), but an indication of its impact is provided by estimate of the amount of carbon stored in forest. Over the period 1990–2005, global forest carbon stocks declined, in percentage terms, but almost doubled the decline in forest area (UNEP, 2007; Raihan *et al.,* 2021). Given the current emphasis of global forest policy initiatives on both deforestation and forest degradation, particularly in the context of the UN REDD+ programme, there is an urgent need not only for improved forest monitoring (Baker *et al.,* 2010; Gibbs *et al.,* 2007; Grainger 2008; Sasaki and Putz 2009), but for a deeper understanding of the processes responsible for forest degradation and their potential impacts on forest biodiversity.

In Nigeria, despite ongoing research efforts on LULC patterns; there remains a need for development of basic datasets providing quantitative and spatial land use/land cover information. In many States of Nigeria, relatively little natural vegetation remains untouched by human hands. Rates of forest loss are accelerating due to subsistence agriculture and shifting cultivation. Today, the change in a fotested area is not only restricted to natural forest as forest reserve and plantation in Nigeria are under threat from land-use changes (Tudun-wada *et al.,* 2014; Jande *et al.,* 2018; Ikyaagba *et al.,* 2020). The global drive towards sustainable environments provides critical need for studies on land use/land cover change within forest vegetation to provide useful information to planners and resource managers (Olokeogun, *et al.,* 2014). Moreover, there appears to be a gap in the available information and national decision-making process and rational planning. Therefore, this paper sought to investigate (i.e. map out), identify and quantify the changes in LULC over the years within Kurmin Dawaki Forest Reserve in Kaduna State, Nigeria using remote sensing and GIS technologies thus ascertaining the deriving factors behind these changes.

MATERIALS AND METHODS

Study Area

Zangon Kataf LGA is located between latitude 10.5167^{O} and longitude 7.4333^{O}. It has a landmass of 2,579 km^2 with a population of 318,991 based on 2006 census. Zangon Kataf Shared boundaries with LGAs like Kachia, Jaba, Jema'a, Kajuru Kaura and Kauru LGA. Zangon Kataf LGA has two distinct seasons, the wet and dry season. The dry season set in November and ends in March while the wet season start in April and end in October with its peak in August. The area is located in Guinea savanna zone of northern Nigeria with mean annual rainfall of 1800 mm, the mean monthly temperature is at 25^{o}C, while the relative humidity is about 62% (Abaje and Giwa, 2007). The orographic effects of the area have positive influence on the climate of the study area influencing rainfall, temperature and relative humidity. Ferruginous tropical soil which is related to the climate, vegetation, lithology and the topography dominate the study area (Hill, 1975). The relief of the area is relatively flat and undulating with lowest relief in the South and South-West of the study area with a height of 180 m rising steadily north and northeastward to about 450 m along the northern edge of the study area and reaching 600 m in the extreme North-East (Chori, 2003). The relief also influences the drainage pattern; most of the study area. The vegetation of the area is made of fire resistance trees species with tall grasses. Some of the tree species are *Parkia biglobosa* (Locust beans), *Khaya senegalensis* (Mahogany), *Azadrachta indica* (neem), *Gmelina arborea, Vitelaria paradoxa* (share butter), and *Eucalyptus camadulensis* among others. Most of the grasses are perennial; they include *Andropogon gayanus, Loudetia flavida, Pennisetum purpureum, Panicumun erimum,* and *Digitaria hirizontalis* among others. The majority of the people are subsistence farmers. Crops produced by the people in the area include; Ginger, yam, Groundnut, soya bean, maize, millet, Guinea corn, sweet potato and rice among others.

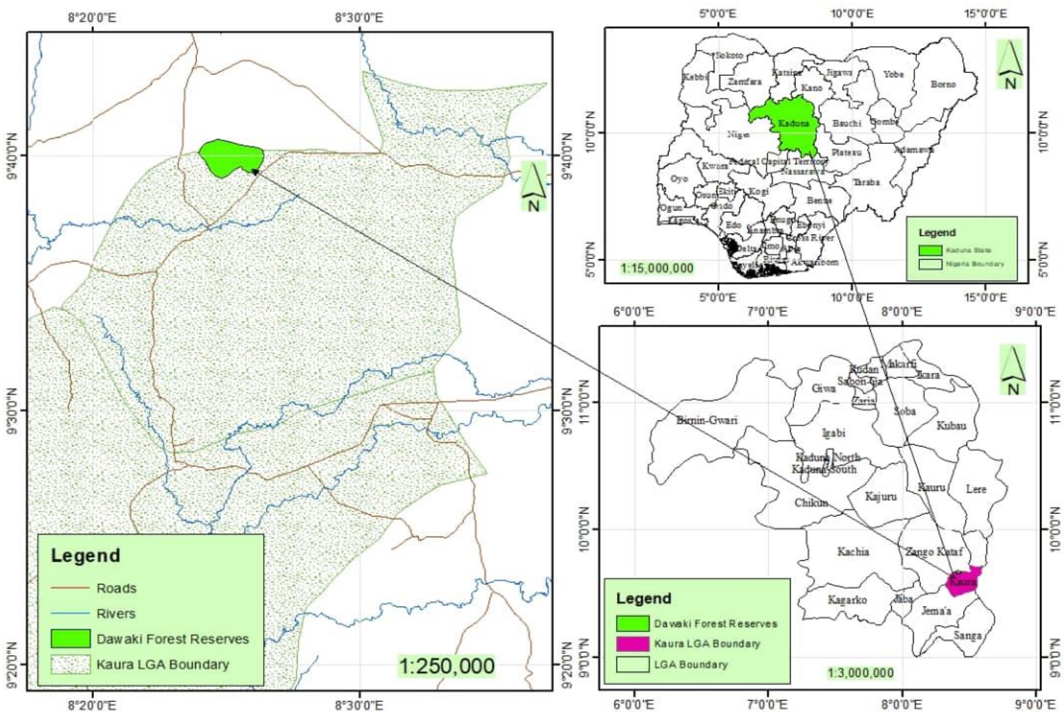

Figure 1: Map of Kaduna State showing Kurmin Dawaki Forest Reserve

Data source and collection

The Landsat 5 TM for 1997, Landsat 7 ETM+ for 2007 and Landsat 8 OLI for 2017 images were sourced from Earthexplorer platform from United States Geological Surveys (USGS). The GPS was also used for ground-truthing during image classification. False colour composite of the images was created and then displayed for visual analysis. Prior to the field exercise, visual image interpretation and analysis was carried out which enabled the identification of different themes on the images based on their spectral characteristics. A subset of the study area was done in ArcGIS 10.3 after a false colour composite of the images were composed. IdrisiTerrSet in image classification employing the maximum likelihood classifier algorithm.

Table 1: Specifications of Satellite Imageries Used

Satellite	Path/row	Sensor	No. of Bands	Band used	Date acquired	Spatial Resolution
Landsat	188/52	TM	7	4,3 and 2	31/01/1997	30
Landsat	188/52	ETM+	8	4,3 and 2	01/02/2007	30
Landsat	188/52	OLI	11	5,4 and 3	25/01/2017	30

DATA ANALYSIS

The tool used for data analysis was ArcGis 10.3 for pre-processing of images. Mapping the types and extent of land use and land cover classes was achieved through the examination of Landsat 5 TM for 1997, Landsat 7 ETM+ for 2007 and Landsat 8 OLI of 2017 images acquired and their subsequent classification. In order to map the types and extent of LULC classes in the reserve. The data were subjected to some processing and analytical procedures which included data processing, image rectification, image enhancement and image classification. Following image processing, composite images for the three study years were created for image classification. This process involved correction of Landsat images through haze removal, cloud removal and clipping the images using the shape file of Kurmin Dawaki forest preserve from the Google Earth. Image enhancement was done to increase the contrast among different features, thereby enhancing easy identification of features and subsequent classification. A band combination of 4, 3, 2 (for RGB) was used for the Landsat 5 TM and 7 ETM+ and 5, 4, 3 for Landsat 8 OLI images as this produced superior result. It is suitable for urban application and delineating of agricultural land, vegetation and forest land. Image classification was done using a supervised classification algorithm which is a procedure for categorizing spectrally similar areas on an image by identifying site of known and generalizing those spectral signatures to other areas of targets that are unknown. A maximum likelihood algorithm of supervised classification was adopted because it is one of the best classification methods which assign pixels to the class with the largest probability to determine class ownership of a particular pixel. Training sites were selected using the field survey data, through visual interpretation, of a composite of the satellite images and making reference to Google Earth images. The statistics of the spectral data associated wirh the training site were used to classify each pixel in the satellite images into the corresponding LULC classes. The statistics of the land used category were extracted. Field work was done so as to collect geographical data from mapping land cover and for accuracy assessment of the land used category.

In order to ascertain the areal extent and rate of change in the LULC in Kurmin Dawaki forest preserve, the following variables were computed. Total area (T_a), Changed area (C_a), Change extent (C_e) and Annual Rate of change (C_r). These variables can be described by the following formula as given by (Yesserie, 2009)

$C_a = T_a(t_2)-T_a(t_1)$ ………. [1]
$C_e = C_a/T_a(t_1)$ …………… [2]

Where:
t_1 and t_2 are the beginning and ending time of the land use and land cover studies conducted.

Training sites were selected using the field survey data, through visual interpretation, of a composite of the satellite images and making reference to Google Earth images. The statistics of the spectral data associated with the training sites were used to classify each pixel in the satellite images into the corresponding LULC classes. The statistics of the land area coverage of the vegetation classes in the three study years were extracted. Fieldwork was done so as to collect geographical data from mapping land cover and for accuracy assessment of the land cover classification. Ground-truth data was alsocollected on spatial features from the study area, such as spatial location, land cover and land use, road network with the aid of a GPS. Ground truthing enabled the collection of inference data and to increase ones' knowledge of land cover conditions. It also enables familiarity of features as it appears on the satellite image on the computer screen, for verification and validation of the interpreted results. The process of identifying and transferring ground points onto the screen was done using the GPS. Each LULC class was physically identified in the field and the position of the area recorded using GPS which was later transferred to the image whereby it was easier to identify the appearance of such land uses on the screen. Inaccessible areas were complemented with the use of Google earth images. In summary, both visual interpretation and digital image classification methods were employed in data interpretation.

Accuracy assessments of the classified maps (1997, 2007 and 2017) were done using the error matrix (ERRMAT in Idrisi Selva). The error matrix assesses accuracy using four parameters which include overall accuracy, user's accuracy, producer's accuracy and the Kappa Index of agreement (KIA). The overall accuracy specifies the total pixels correctly classified and is derived by dividing the total number of pixels correctly classified by the total number of pixels in the error matrix. The producer's accuracy defines the probability of a reference pixel being correctly classified. It represents the error of omission. The number of samples correctly classified for a given column is divided by the total for that column. The user's accuracy, on the other hand, defines the probability that a pixel classified on a map actually represents that category on the ground. User's accuracy represents the error of commission. This can be calculated by dividing the number of samples correctly classified for a given row by the total of the row. On the other, the Kappa index measures the agreement between the classification map and reference data. All accuracy parameters have index values between 0 and 1, where 0 symbolizes poor and 1, strong classification accuracy/agreement.

RESULTS

Land use and land cover map of Kurmin Dawaki Forest

The classified Landsat image of Kurmin Dawaki forest preserve for 1997, 2007 and 2017 was presented in Figure 2-4 below. In addition, the extent and percentage of vegetation classes in the study area were presented in Table 2**.**

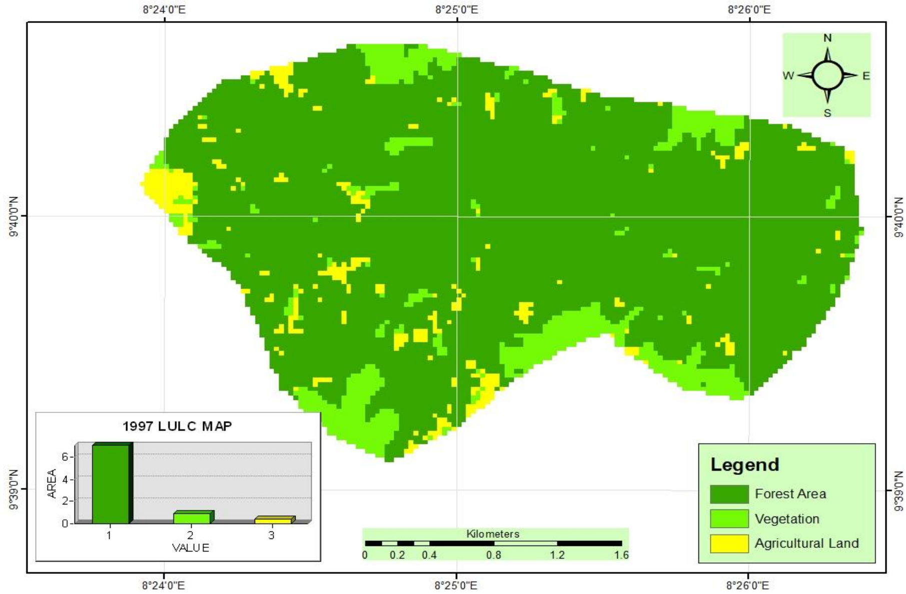

Figure 2: Kurmin Dawaki 1997 LULC distribution map generated from LandSat 5 TM Analysis of land use/land cover map of 1997 satellite imagery for Kurmin Dawaki Forest

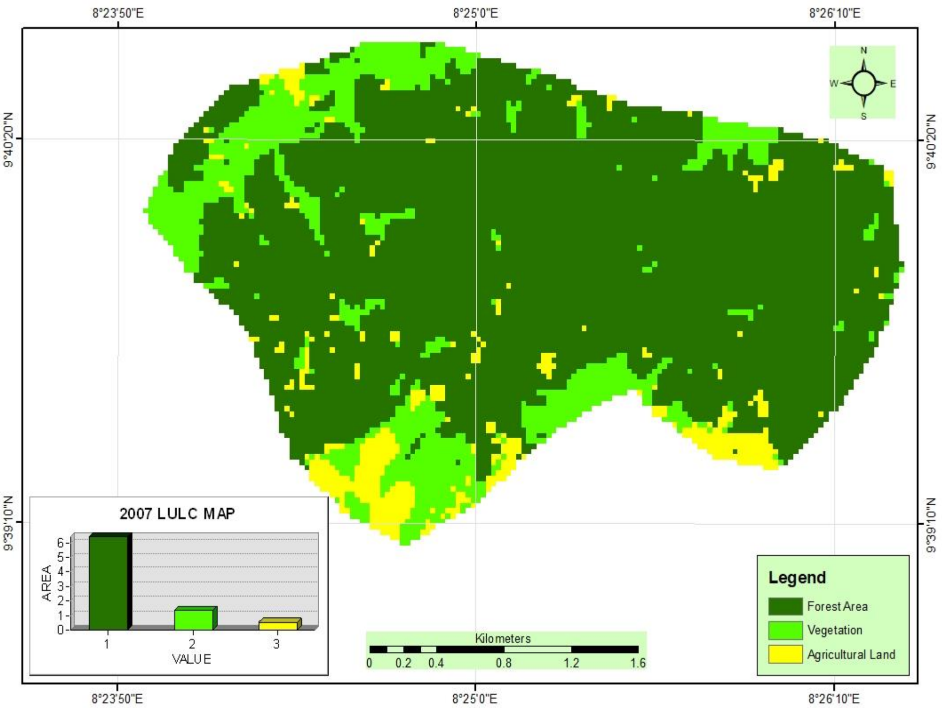

Figure 3: Kurmin Dawaki 2007 LULC distribution map generated from LandSat 7ETM+ Analysis of land use/land cover Map of 2007 satellite imagery for Kurmin Dawaki Forest

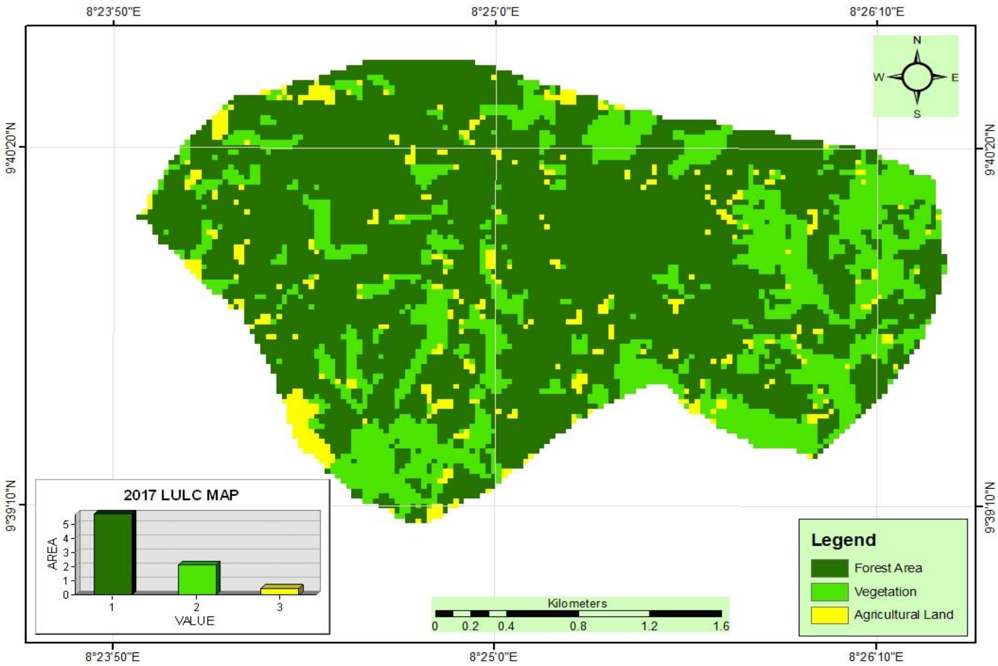

Figure 4: Kurmin Dawaki 2017 LULC distribution map generated from LandSat 8OLI Analysis of land use/land cover Map of 2017 satellite imagery for Kurmin Dawaki Forest

Assessment of classification accuracy of LULC Kurmin Dawaki Forest Reserve

The accuracy of classification for three periods of 1997, 2007 and 2017 showed an overall accuracy of 95.08%, 89.58% and 96.91% with the corresponding Kappa statistics was 0.79, 0.83 and 0.84, respectively (Table 2). In general, the overall accuracy of the classification was consistently high which indicates high level of agreement between classified image and land cover categories on the field.

Table 2. Accuracy Assessment Result of LULC Classification in KurminDawaki Forest Reserve

Class Name	1997		2007		2017	
	Producer's Accuracy (%)	**User's Accuracy (%)**	**Producer's Accuracy (%)**	**User's Accuracy (%)**	**Producer's Accuracy (%)**	**User's Accuracy (%)**
Forest	82.10	90.4	93.21	96.44	86.30	94.12
Grassland/Herbaceous Cover	84	78.24	83.34	87.05	89.5	97.80
Agriculture Land	89.71	90.50	88.71	91.45	97.60	75.40
	83.30	89.70	95.21	88.70	80.51	89.23
Overall Classification Accuracy (%)	**82.80**		**83.40**		**84.71**	
Overall Kappa	**0.79**		**0.83**		**0.84**	

Trend of LULC Changes in Kurmin Dawaki forest preserve

The result of the land use/land cover change in Kurmin Dawaki forest preserve indicates that the agricultural area increased from 0.39 Ha (4.73%) in 1997 to 0.52 Ha (6.24%) in 2007 which represent 0.13Ha increased. Grassland/Herbaceous Cover also increased during the period from 0.87Ha (10.43%) in 1997 to 1.36 Ha (16.44%) in 2007 indicating 0.50 Ha increased. Forest area on the other hand, decreased from 7.04Ha (84.84%) in 1997 to 6.42Ha (77.32%) in 2007 representing -0.62Ha decreased (Table3).

From 2007 to 2017, the result of the land use/land cover change in Kurmin Dawaki forest preserve revealed that the Agricultural area decrease from 0.52 Ha (6.24%) in 2007 to 0.44 Ha (5.27%) in 2017. However, grassland/herbaceous cover increased from 1.36 Ha (16.44%) in 2007 to 2.12 Ha (25.63%) in 2017. Furthermore, forest area decreased from 6.42 Ha (77.32%) in 2007 to 5.72 Ha

(69.1%) in 2017 representing -0.7Ha decreased (Table3)

The result of land used land cover change in Kurmin Dawaki forest preserve from 1997 to 2017 indicate that Agricultural area increase from 0.39Ha (4.73%) in 1997 to 0.44 (5.27%) in 2017 representing 0.05Ha increase. Grassland/Herbaceous Cover also increased from 0.87Ha (10.43%) in 1997 to 2.12Ha (25.63%) in 2017 representing 1.25Ha increase. Forest cover on the other hand decreased from 7.04Ha (84.84%) in 1997 to 5.72Ha (69.1%) in 2017 representing -1.32Ha Decrease (Table3).

Table 3: Land use and Land cover Distribution of Kurmin Dawaki (1997, 2007and 2017)

Classification Category	1997		2007		2017	
	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)
Forest area	7.0407	84.84	6.417	77.32	5.7177	69.1
Grassland/Herbaceous Cover	0.8658	10.43	1.3644	16.44	2.1213	25.63
Agricultural land	0.3924	4.73	0.5175	6.24	0.4365	5.27
Total	8.2989	100	8.2989	100	8.2989	100

Magnitude of Land use/Land change

The magnitude of change of forest cover for 20 years period at Kurmin Dawaki forest preserve from 1997 to 2017 reveal that the forest is on the decline as it lost 1.32 ha (18.792%) to other land cover classes with annual rate change of 0.23% this implies that 0.23% of forest land is been lost annually in the reserve for 20 years. Grassland/Herbaceous Cover increase by 1.26ha (145.01%) between 1997 and 2017 at an annual rate of 0.59% this result indicates that 0.59% of Kurmin Dawaki forest preserve is being converted yearly to Grassland/Herbaceous Cover during the period under study. Similarly Farm land increase by 0.04ha (11.24%) at an annual rate of 0.10% this result also indidcate that 0.10% of Kurmin Dawaki forest preserved is being converted yearly to farmland.

Table 4: Magnitude and Percentage of Change in LULC between 1997 and 2017

Forest Reserves	Land uses	1997	2017	Magnitude of change	Percentage change	Annual rate of Change (%)
Dawaki	Forest area	7.041	5.718	-1.323	-18.791	0.231
	Grassland/Herbaceous Cover	0.866	2.121	1.256	145.010	0.592
	Farm Land	0.392	0.437	0.044	11.239	0.101

DISCUSSION

Trend of LULC Changes in Kurmin Dawaki Forest Reserve in 1997 2007 and 2017

Kurmin Dawaki forest reserve witnessed an increase in human activities within 20 years period between 1997 to 2017. The result also shows some level of modification in the land cover of the forest reserve during the first 10 years from 1997 to 2007. It was noticed that there was an increase in the proportion of Agricultural area and Grassland/Herbaceous cover increased while forest area decreased. The high increase in Agricultural area was observed between 1997 to 2007 while that of Grassland/Herbaceous cover was noticed between 2007 to 2017. The high level of decrease in forest area was recorded between 2007 to 2017. Similar trends were reported Tudun-Wad *et al.* (2014) in Nimbia Forest Reserve, Kaduna State, Nigeria Jande *et al.* (2018) in Yandev forest reserve Benue State, Nigeria Orimaye *et al.* (2018) in Idanre Forest Reserve, Nigeria, Aderele *et al.* (2020) Ago-Owu Forest Reserve, Osun State, Nigeria and Ikyaagba *et al.* (2020) in Benue State. Jande *et al.* (2018), Orimaye *et al.* (2018) and Ikyaagba *et al.* (2020) noted that land use/land cover change within and around forest reserves and plantations mostly in Nigeria area due to increase in population. As the population around the reserve increases, so the pressure on the reserve also increases because more land is needed for food production. Consequently, in the absence of good protection, forest reserves may become fertile ground for agriculture. Aderele *et al.* (2020) opined that soils in forest reserves are often more fertile than other surrounding soils which increase demand for them for agricultural purposes. The high percentage of farmland, Grassland/Herbaceous cover witness in the area could be due to the increased in farming activities in the area

The magnitude of Land Use and Land Cover Change

The 20 years period from 1986-2019, witness increased in magnitude of the change of the forest area with an increase in the Grassland/Herbaceous Cover. Within the period -1.323ha of forested area was lost to other land uses, while Grassland/Herbaceous Cover gained 2.121ha of the total area of the reserved. Though there were increased in Agricultural area and Grassland/Herbaceous Cover the figures were less that the magnitude recorded by Orimaye *et al.* (2018) in Idanre Forest Reserve, Nigeria, Aderele *et al.* (2020) Ago-Owu Forest Reserve, Osun State, Nigeria and Ikyaagba *et al.* (2020) in Benue State. The magnitude of change of Grassland/Herbaceous cover observed in the study could be an indication that agricultural activities within the reserve are on decrease.

Conclusion and recommendation

There was sufficient evidence from the study that there were severe changes in the Land use and Land cover in Kurmin Dawaki forest preserve in the past 20 years, beginning from 1997 to 2017. It was detected that forest land cover was most affected land use category with Grassland/Herbaceous Cover being the major gainer of the change. This result indicates that 145.01% and 11.23% of Kurmin Dawaki forest preserve is being converted yearly to other Land uses. It was recommended that there should be increased monitoring of forest plantation in the study area to avert the current rate changes being experienced in the plantation. Planting of tree species in the already degraded areas of the plantation should be encouraged in order to argument the lost forest. This shows that under good management and protection our forest reserved and natural forest will be saved.

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