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CONSEQUENCES OF FIRES - BURNT AREA AND LAND-USE CHANGE OF OLD OYO NATIONAL PARK, NIGERIA

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ABSTRACT

Fire incident is a naturally occurring process in terrestrial ecosystems and serve as a tool for changing land use. Fire can exercise significant transition impacts on the biosphere, hydrosphere, geosphere, cryosphere, atmosphere and humanity. The need to finding such knowledge is of great value in advancing the understanding of fire ecology and promoting sustainable fire management. The study aimed consequences of fires-burnt area and land-use change at Old Oyo National Park, Nigeria. The satellite observations of long-term ESA CCI land cover (300 m resolution) and burnt area data from MODIS collection 6 (500 m resolution), MCD64A1 dataset were used to assess the post-fire land cover change patterns from 2000to 2024. This dataset categorizes burnt areas by land use (forest, grassland, shrub land, and wetland) on yearly basis. The total burnt-areas of 88 sample points were assessed in 2558 area (ha) of the study area. As indicated in the results, grasslands took the highest burnt areas throughout the period. In 2005, grasslands and forests showed the highest burnt area. The change matrix for burnt areas focusing on the transitions between land-use types indicated that the forest area tends negative with the value of -17 ha and a percentage of -1.85 ha. Grassland area has a reduction of -61 ha and also a percentage of -3.67 ha. The grassland transition could indicate forest degradation due to fire, leading to a shift in vegetation type. Shrub land fire have positive tendency of 8ha with 100 percent increase in 2024. This can invariably reduce biodiversity, alter carbon storage, and impact wildlife habitats of the area.

Keywords: MODIS, Change matrix, fire-management, biodiversity

Introduction

Human activities and land management practices influence wildfire activity. Over time, wildfire management strategies have changed, shifting from policies focused on preventing all wildfires to approaches that combine wildfire suppression with controlled burns to reduce wildfire risk. Therefore, understanding changes in fire characteristics requires long-term records, a regional perspective, and consideration of many factors, such as topography, fuel load, weather, ignition sources, land use and climatic drivers, (Stein *et al.* 2013).Fire occurrence and spread are controlled by complex factors such as climate conditions, vegetation states, ignition foci, anthropogenic activities and their interactions (Flannigan *et al.*, 2009; Andela *et al.*, 2017; Jones *et al.*, 2022; Senande-Rivera *et al.*, 2022).

Therefore, accurately mapping the spatiotemporal patterns of global burnt area is essential for understanding mechanisms of fire disturbances, quantifying the global

carbon budget and local energy balance (Mouillot *et al.*, 2014).In spite of the stretched history of the use of fires to clear the area for grazing, large-scale vegetation density in the Pantanal region has largely remained unaffected by such activities (Pott *et al*, 2004), particularly over the conservation areas., and found that approximately 3.7 Mha burnt, representing 28.9% of the region burnt from the 2020 fires, corroborating data from the ALARMES warning system (Libonati,*et al*., 2021) from the Laboratory for Environmental Satellite Applications (LASA-UFRJ; https://lasa.ufrj.br/alarmes).Justifications for studying the consequences of fires, burnt areas, and land-use changes in Old Oyo National Park (OONP), Nigeria, center on the need to protect the park's fragile savanna ecosystem from irreversible degradation.

Research in this area provides the empirical data necessary to balance rural livelihoods, mitigate climate-induced fire risks, and optimize conservation strategies. The study investigated changes in fire-affected areas across different land-use categories in and around Old Oyo National Park, Nigeria. The data compare fire regimes in 2024 with those in 2000, focusing on areas classified as burnt by the MCD64A1 dataset. This analysis provides insight into how changes in fire regimes influence ecosystems and land management practices in and around Old Oyo National Park, Nigeria. The land-use data were derived from the MCD12Q1 product for the year preceding each fire event. Combining these datasets provides valuable insights into the complex interactions among fire, land use, and the environment in and around Old Oyo National Park, Nigeria.

Materials and Method

Study area: Old Oyo National Park, Nigeria

Old Oyo National Park is one of the National Parks in Nigeria, located across northern Oyo State and southern Kwara State, Nigeria. The Park has total land mass of 2,512 $km^2$and is located in southwest part of Nigeria, specifically Northern Oyo State at latitude 8^o 15' and 9^o 00'N and longitude 3^o 35' and 4^o 42'E. The location has inevitably placed the Park at a vantage position of abundance land area as well as diverse wildlife and cultural/historical settings. The Park derives its name from the ruins of Oyo-Ile (Old Oyo) the ancient political capital of Yoruba Empire. The Park is made up of two previous Native Administrative Forest Reserves, the Upper Ogun (1936) and Oyo-Ile (1941) Forest Reserves. These unique ecosystem and historical relics were converted to Game Reserves in 1952 and finally upgraded to the present status of a National Parks **(**Omolere *et al*, 2016**).**

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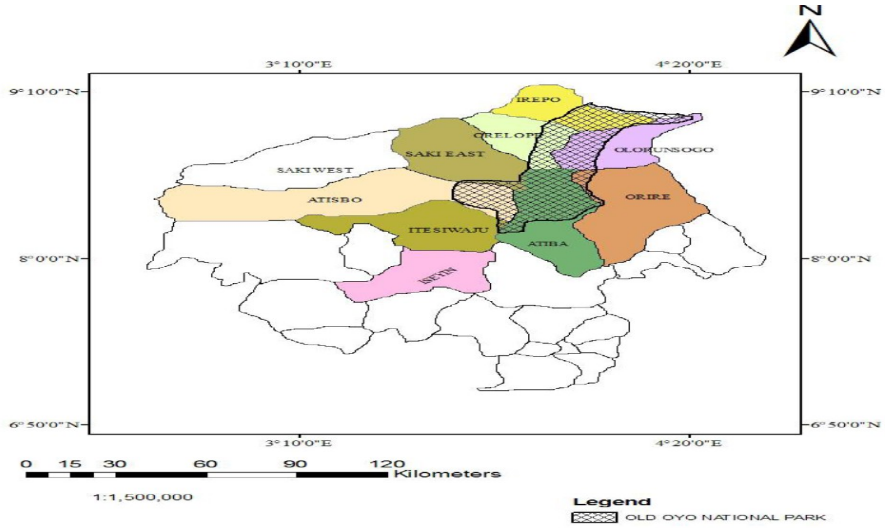


Figure 1. Old Oyo National Park, Nigeria

Remotely sensed data was used to estimate burnt areas to examine the changing influence of fire instances over time and how the historical occurrences of fires increase over the natural areas and reduce over heavily managed regions. Fire trends within Old Oyo National Park, Nigeria was analyzed using data from the MCD64A1 dataset.

This dataset categorizes burnt areas by land use (forest, grassland, shrub land, and wetland) on a yearly basis. Understanding these trends is essential for effective park management, biodiversity conservation, and evaluating the ecological impacts of fire. Land-cover data were derived from the ESA Climate Change Initiative Land Cover (CCI-LC) dataset corresponding to the year preceding each fire event.In this study, we used burnt-area estimates from the MODIS Burnt Area Product (MCD64A1), derived from the Moderate Resolution Imaging Spectroradiometer (MODIS)sensor aboard the NASA Terra and Aqua satellites (MCD64A1) (Giglio *et al*., 2018)to assess fire dynamics across the study area..The MCD64A1 dataset provides monthly, 500-meter resolution data on burnt areas globally, derived from MODIS (Moderate Resolution Imaging Spectroradiometer) data. It is a Level-3 product, meaning it is gridded and contains information about burn date, uncertainty, and quality assurance (QA) for each pixel. This dataset is crucial for monitoring and studying fire activity and its impact on ecosystems.

Table 1: Number of samples for different vegetation types.

SNo	Vegetation cover type	Area (ha)	Total number of Burnt Areas
1.	Forest	918	25
2.	Grassland	1,662	52
3.	Grassland	8	3
	TOTAL	2558	80

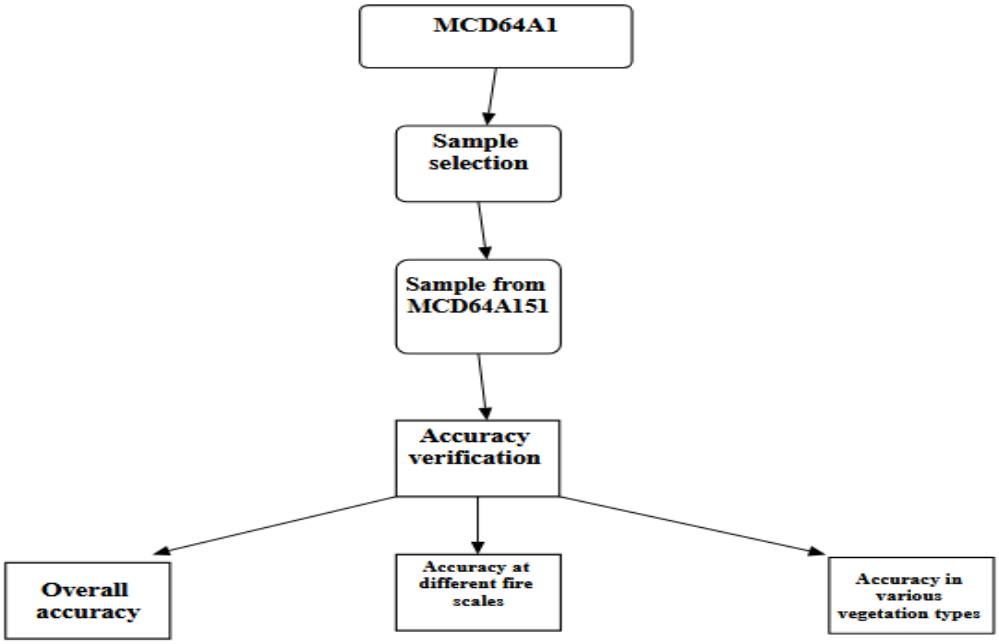


Figure 2. Technical flow chart of the methods.

Results

Table 2: Fires-burnt area and land-use change of Old Oyo National Park, Nigeria

YEARS	GRASSLAND	FOREST	SHRUBLAND	WETLAND
2000	7328.5	3715.3	813.0	0
2001	68210.0	60509.0	3075.7	17.7
2002	41956.3	41419.5	1642.6	8.8
2003	47404.3	40977.3	2500.2	26.6
2004	30271.8	21091.1	1340.7	26.6
2005	93274.9	74691.6	5105.4	26.6
2006	50315.8	45711.7	2822.9	17.7
2007	30042.0	26028.0	982.6	17.7
2008	36708.4	27998.0	1909.1	17.7
2009	30727.9	22015.9	2076.1	44.3
2010	42598.2	22015.9	1944.1	0
2011	58509.6	31671.9	2957.5	17.7
2012	38702.3	25344.7	2411.8	26.6
2013	38015.3	20490.5	1988.1	8.8
2014	30737.0	24860.8	1450.7	26.6
2015	37834.4	19763.9	1305.8	0
2016	57694.5	35599.1	2175.7	8.8
2017	14280.9	13911.9	482.1	8.8

2018	6538.4	4705.4	88.5	0
2019	13233.3	7665.1	618.9	0
2020	25966.8	23703.1	1781.8	8.8
2021	24659.8	23485.9	2238.8	8.8
2022	20614.8	15230.7	1777.8	0
2023	45736.1	34232.9	3481.3	26.6
2024	31577.7	18011.2	976.3	0

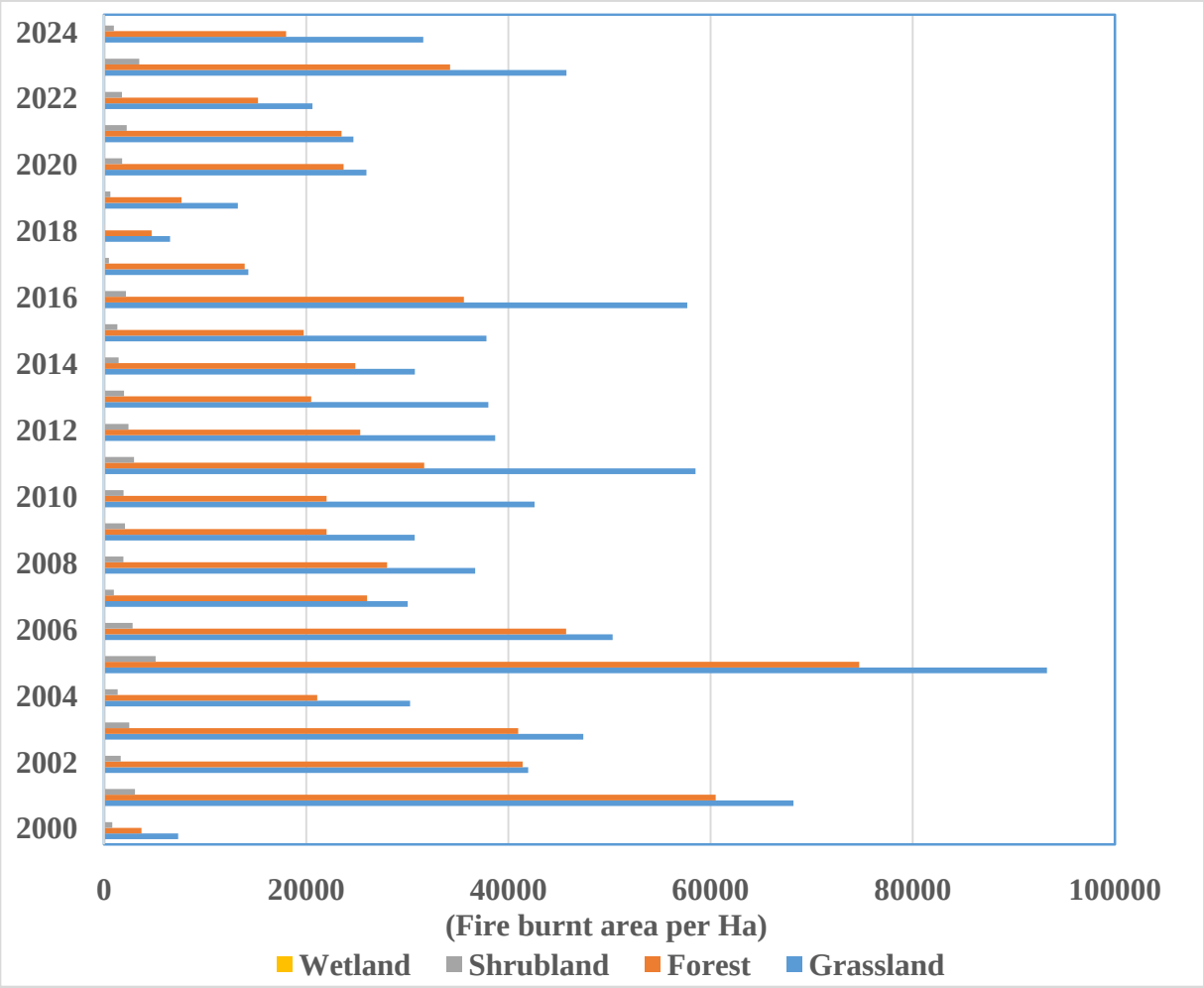


Figure 3: The historical trends (2000–2024) Fires-burnt area and land-use change of Old Oyo National Park, Nigeria

The results showed that forest conversion to grassland creates major spikes in burnt area (especially during hot and dry conditions). The historical trends (2000–2024) in areas per hectare and years in MODIS-burnt area and land cover type (Grassland, forest, shrub land,

and wetland) as shown in figure 3. It highlights the influence of the land use changes over the years. Unusually, it was found that under similar drought conditions, natural landscapes were most sensitive to fire extremes.

Grasslands took the highest burnt areas throughout the period of years. In 2005, grasslands and forests showed the highest burnt area. The advance of new forests and especially new wooded vegetation such as shrub lands, as well as the reduction of grasslands and pastures, is more evident within burnt areas than in the rest of the unburnt territory; this can be interpreted as a fire preference for these particular land-use changes. Large fires (> 500 ha) affected areas with higher rates of forest expansion, and recurrent fires tended to occur in areas with higher transitions from abandoned pastures and grasslands towards shrub lands. Vegetation disturbance from fires is an essential component of savanna and woodland ecosystems.

Table 3 Change Matrix for 2000-2024 (Ha) fire -burned area by land use Old Oyo National Park.

SNo	Categories (Ha)	FF	GF	SF	TOTAL
1.	Forest fire	840	70	8	918
2.	Grassland fire	61	1601	-	1662
3.	Shrubland fire	-	-	8	8
4.	TOTAL	901	1,671	16	

Table 4: Summary of changes fire-burned area by land use Old Oyo National

S/N	Ha	Total Area (2000)	Total Area (2024)	Change in Area	Change in Area (%)
1.	Forest fires	918	901	-17	-1.85
2.	Grassland fires	1,662	1,601	-61	-3.67
3.	Grassland fire	8	16	+8	100

Discussion

The change matrix for burnt areas in Old Oyo National Park, focusing on the transitions between land use types from 2000 to 2024 (as modeled based on the provided data).The table 2 provided is a "change matrix." It shows how many hectares (ha) of burnt area transitioned from one land use type in 2000 to another in 2024. Rows (2000 Land Use): Each row represents the land use type in the year 2000 before a fire occurred. For example, the first row is "2000: Forest Fires (ha)".Columns (2024 Land Use): Each column represents the land use type in the year 2024 after a fire occurred. For instance, the first column is "2024: Forest Fires (ha)". Cells (Transition (Ha):

The numbers within the tables 2 and 3 show the area (in hectares) that transitioned from the row's land use in 2000 to the column's land use in 2024.For instance, the cell at the intersection of "2000: Forest Fires (ha)" and "2024: Forest Fires (ha)" is 840. This means that 840 hectares that were classified as "Forest Fires" in 2000 were still classified as "Forest Fires" in 2024.The cell at the intersection of "2000: Forest Fires (ha)" and "2024: Grassland Fires (ha)" is 70. This means that 70 hectares that were classified as "Forest Fires" in 2000 were classified as "Grassland Fires" in 2024.The "Total 2000"

column shows the total burnt area for each land use type in 2000. The "Total 2024" row shows the total burnt area for each land use type in 2024.This study expands on previous research concerning the Amazon fire-transition process related to land-use transitions (Tavares *et al*,2022) and opposing responsesof fire to human activities in the Amazon and Cerrado (Rosan, *et al*, 2022). Theoccurrence of active fire detections was establish to be higher during the transitions fromforest to shrub land rather than forest to pasture (Morton, *et al* 2008).As drought conditions further increase forestsusceptibility to fire, forested landscapes are vulnerable to increased deforestation and global warming (Brando, *et al*. 2020)

Trends and Patterns from the change matrix:

Forest Fires Persistence: A significant portion of areas classified as "Forest Fires" in 2000 remained as "Forest Fires" in 2024 (901 ha). This suggests that some areas are experiencing repeated or prolonged burning that prevents them from transitioning to other land use types. **Grassland Fires Persistence:** The largest area of burnt land in 2024 is classified as Grassland Fires, with 1601 hectares remaining as grassland fires. Transition from Forest to Grassland: A notable area (70 ha) transitioned from "Forest Fires" in 2000 to "Grassland Fires" in 2024. This could indicate deforestation or forest degradation due to fire, leading to a shift in vegetation type.

Implications of transition

Ecosystem Change: The transition from forest to grassland due to fire can have significant ecological consequences. It can reduce biodiversity, alter carbon storage, and impact wildlife habitats.

Land Management: The persistence of forest fires suggests that current fire management strategies may not be fully effective in preventing repeated burning in certain areas.

Climate Change: Changes in fire regimes can be both a cause and a consequence of climate change. Increased fire frequency and intensity can release more carbon into the atmosphere, further exacerbating climate change.

Conclusion

Uncontrolled wildfire regimes in Old Oyo National Park, Nigeria pose a severe threat to ecological stability, biodiversity, and human life. The fire data showed that grasslands are the most frequently burnt land use type, with significant year-to-year variability. The Implications of transition from forest to grassland due to fire can have significant ecological consequences. This can invariably reduce biodiversity, alter carbon storage, and impact wildlife habitats of the area. To effectively mitigate this threat, fire safety resources must shift from reactive suppression to a proactive, data-driven approach

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