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Trends of Land Use and Land Cover Change in the Savannah Ecological of the Protected Area Reserve Partielle de Dosso, Niger

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Abstract

Information on the dynamics of savannah is important to a country's plan to overcome the problems of uncontrolled development and environmental hazards. Taking the reserve partielle de Dosso, Niger as the case study area, this paper analyzed the long-term land use land cover change from 2002 to 2022. Satellite images were processed by using Google Earth Engine (GEE). Therefore, four major land cover classes were identified based on spectral characteristics of Land sat, namely, built-up, vegetation, cropland, bare land and water. The result revealed that barren and built-up areas increased at the expense of vegetation and water. From the four major land use land cover the large area is covered by vegetation which comprises about 192963.5 hectares followed by cropland and water consisting of 32506.43 and 1596.4 hectares respectively. The built-up area gained substantial area (most) during the study period. The reduction in some of the land cover/uses underlines the dangerous trend of the pressure poised by population growth and the changing functionality. Land cover change is influenced by a variety of societal factors operating on several spatial and temporal levels. The area estimates and spatial distributions of the LULC classes produced from the current study will assist local authorities, managers, and other stakeholders in decision-making and planning regarding forest land cover and uses.

Keywords

Land Use/Cover, Change Detection, Classification, Dosso

1. Introduction

Niger is a sensitive region where identifying land cover change is critical to understanding global environmental change. Deforestation and habitat loss in Niger are the two major environmental changes because of their impact on the increase of biodiversity loss [1]. The reserve partielle de Dosso is one of the largest contributors to the Nigerien mega diversity [2]. This protected area is a priority area for systemic functioning and as a critical biodiversity area. It provides several services such as climate regulation, provisioning of plant and animal resources, recreation and socio-cultural services [3]. However, many forests globally are threatened by land use and land cover (LULC) change directly proportional to the human growth rate [4]. Furthermore, the reserve presents several indicators of disturbance like agricultural intensification, habitat fragmentation, and overexploitation of its resources [5]. Agricultural expansion with the degradation of natural vegetation cover, is the most dominant trajectory of land use and land cover change in tropical regions [6]. The reserve partielle de Dossois vulnerable to human-induced factors such as land degradation and high population intensity due to its strategic location, access to roads, and available land and water resources.

Like most reserves, the reserve partielle de Dosso is encroached on by local populations through the use of the land for agriculture and unsustainable wood extraction [7]. The reserve is the main source of firewood supply for the surrounding cities and gradually the activities carried out there have led to its degradation [7]. The global demand for food and bioenergy changes associated with land use and land cover change (LULCC) has raised concerns about the environment, global warming, and climate change.

Evaluating vegetation cover loss in reserves can provide valuable information for the analysis of the environmental impacts of population pressure, agriculture, urban expansion, resettlement programs, climate change, and others. This analysis provides accurate information related to LU/LC changes and a baseline for sustainable reserve management and conservation.LU/LC study is vital for the development and planning of appropriate environmental management policies and strategies [8]. Therefore, this study aims to assess the evolution of land use and land cover in the reserve through a diachronic analysis of satellite images over two different periods (2000 and 2022). In addition, the activities and the perceptions of the surrounding populations on the changes that this reserve has undergone over the years have been assessed.

2. Methods

2.1. Study Site

The reserve partielle de Dossois adjacent to the W Park and located on the left of the Niger River, is the only protected area in Dosso. With an area of 306,000 ha, it is marked by the influence of human activities. It is located between 11˚53'9.59" N 3°26'28.79" E. The climate is Sudano Sahelian type characterized by two seasons: one rainy season from mid-May to mid-October and one dry sea-

son from mid-November to mid-March. The average rainfall is 904.9 mm/year, and the average annual temperature is 27.8˚C [7]. The soils fall into two main categories: poorly evolved soils. The natural vegetation is dominated by shrub savannah characterised by the presence of *Vitellaria paradoxa C.F.Gaertn*, *Prosopis africana* (Guill. & Perr.) *Taub. Sclerocarya birrea* (A.Rich.) *Hochst., Vitex doniana Sweet, Guiera senegalensis JF Gmel, Detarium microcarpum Guill. & Perr., Balanites aegyptiaca Delile*.

2.2. Dataset

Landsat satellite images captured in 2000, and 2022 were used to analyze the dynamics of land-use change over the last 22 years in the reserve partielle de Dosso. These years were selected to detect the possible change occurring at short and long spans, beginning from the most recent year. Consideration was also given to the availability of cloud-free images for the reserve. The images were downloaded from the United States Geological Survey (USGS, https://earthexplorer.usgs.gov/) earth explorer.

2.3. Method

We used the Google Earth Engine (GEE) cloud computing platform to create cloud-free data. LULC images were generated using a pixel-based Maximum Likelihood (MLC) unsupervised classification method. Unsupervised classification was performed on two satellite images for the years 2000, and 2022 to identify differences in land cover. The feature classes were categorized by unsupervised classification according to the spectral reflectance of the electromagnetic spectrum, which has specific spectrum characteristics with the integration of a real ground survey [9]. Microsoft Excel 2016, which was used in computing the LULC changes to show their percentages and change rates in the study area. In addition, a non-parametric Kappa test was also performed to measure the extent of classification accuracy as it not only accounts for diagonal elements but for all the elements in the confusion matrix [10].

The image was classified into five classes namely: Waterbody, Built up areas, Barren/bare land, Vegetation and Cropland (**Table 1**).

Table 1. Landcover classification scheme.

Land cover	Description
Water body	Lakes, reservoirs, stream, rivers, swamps
Built up areas	Land covered by buildings and other man-made structures. Residential; mixed urban or built up lands
Barren/bare land	Lands with exposed soil, sand or rocks, and never has more than 10% vegetated cover during any time of the year. Bare ground, bare exposed rocks, quarries and gravel pits
Cropland	Lands covered with temporary crops followed by harvest period, Crop fields and pastures
Vegetation	Lands with woody vegetation

3. Results

3.1. Trends in Land-Use Change

On trends in land cover change, analysis of vegetation change across the reserve between the years 2000 and 2022 reveals an overall change of 28% of the total annual integrated vegetation index of the reserve (Figure 1 and Figure 2). Large parts of the reserve experienced various forms of change within the twenty-two years, while lower in extent and intensity of change were notable across the reserve. The spatial distribution of changes indicates a more sustained decrease in the reserve partielle de Dosso. Changes in land use and land cover in the reserve potentially affect a wide range of socio-economic and environmental processes.

If we refer to the scale [9], these values of Kappa index (Table 2) prove that the classifications performed are reliable.

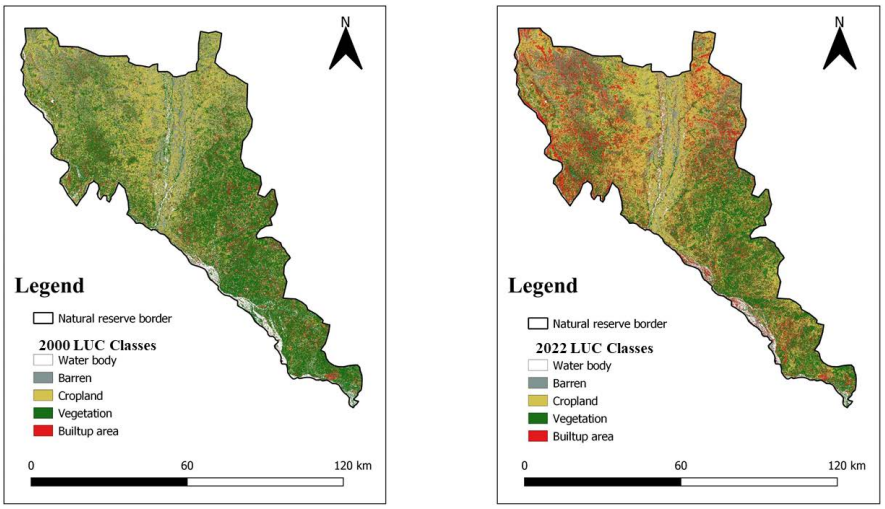

Figure 1. Land use changes in the reserve partielle de Dosso.

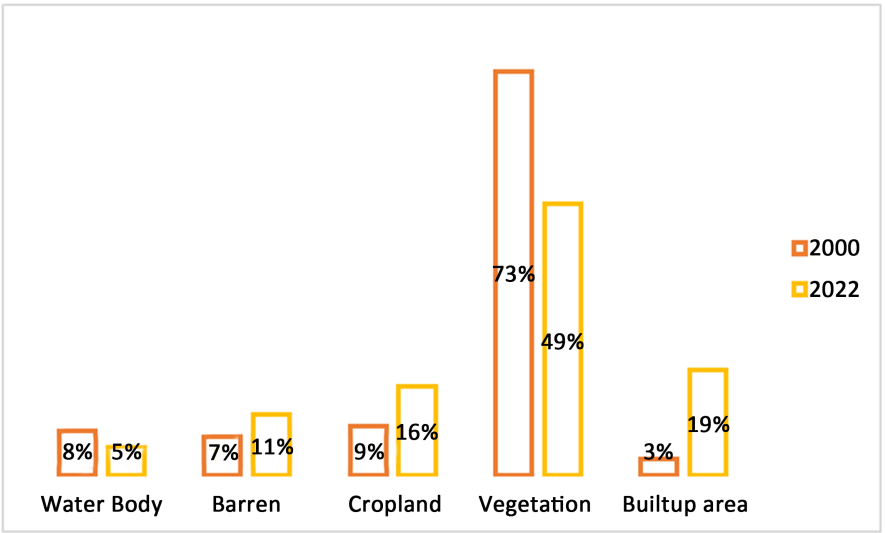

Figure 2. Proportions of the different types of land-use.

Table 2. Values of overall accuracies and Kappa index.

Landsat imagery	Overall errors (%)	Overall accuracies (%)	Kappa index
7ETM + of 2000	13	87	0.82
8OLI of 2022	10	90	0.85

3.2. Land use and Land Cover Changes

Urbanization is one of the most pressing environmental problems facing the reserve partielle de Dosso. It increased loss of biodiversity through the fragmentation of the reserve into isolated patches surrounded by anthropogenic habitats. The urbanization rate increased from 7.6% in 2000 to 32.6% in 2022.The reserve has over three quarters of their vegetation cover depleted, and it is estimated that if current trends continue, the reserve, will experience a severe shortage of ecosystem services and goods. After urbanization, the expansion of cultivation has primarily targeted fertile lands where agricultural production can be sustained. Land is scarce within the reserve due to high population and conservation measures are not enforced.

3.3. Drivers of Land-Use Change

For this reserve, population increase is the major driving force for land-use change. The increase in population apparently translates into expansion of cultivation and settlement areas. Increased focus on commercial agricultural production is another driver of agricultural expansion. As people change from subsistence farming to the production of commodities for local and external markets, the need for larger farms increases in order to produce enough to sell for higher income. People cultivate more land in order to produce enough. In many parts of the reserve, land degradation has reduced productivity of the land leading to poor yields. Similarly, the declining quality of pastures because of land degradation makes livestock and wildlife graze on wider orbits thus demanding more land for grazing.

Urbanization around the reserve is another cause for land-use change. Close to the reserve, municipal centers have created markets for food commodities coming from the reserve and thus the increase in demand in town results in an in-crease in demand for supplies of food produced in the rural areas.

3.4. Impacts of Land Use on Agricultural Production and Livelihoods

Changes in land use have resulted in land fragmentation, over-cultivation, and reduced fallow periods leading to a decline in land productivity and ultimately in intensification of agriculture requiring more farm inputs. The extent and quality of grazing lands have also been reduced, thus intensifying conflict between the cultivators and the herders and even overgrazing by herders and agro-pastoralists due to continuous grazing without rest from grazing or rotation grazing plans.

4. Discussion

Estimations indicate that 50 percent of the reserve partielle de Dosso land surface has been affected or modified in some way by human activity [7], with a strong influence on the existence of vegetated land. [11] confirmed that expansion of cropland and pasture (grazing in this study) accounted for 96% of the cases causing deforestation. [12] has emphasized that agricultural expansion is the most important proximate source of tropical deforestation. The increase in population and development of cities has led to land conversion with lesser vegetated areas., i.e. 49% to 73%.On the contrary, the spatiotemporal representation found rapid urbanization; Built-up areas gained a substantial area (most) during the study period with an annual average deforestation rate of 3551 ha.

Land-use changes driven by human activities are a consequence of any development. As stated by [13], farmland, vegetation areas are converted to construction land due to urban expansion along with economic and social development.

The conversion from vegetation to standing built-up area, crop land, and barren was mainly driven by urban household dynamics, population growth, distance to cities and major roads, and precipitation dynamics. It is estimated that this process of agricultural extensification, coupled with deforestation and other land use changes, translates to a conversion of 4% of the land from tree cover to bare soil over this period. Cropland expansion is a major factor in vegetation loss and wildland fragmentation. This finding is in agreement with results from previous studies ([7] [8] [12]). Water features also decreased from 8% in 2000 to 5% in 2022, with net decline of 2.18 km^2. Water area decrease is occurred due to the gradual conversion of water spread area into built-up area or human developmental area. It also may cause by climate change effects example drought, lack of rainfall, and temperature rise. Shortage of water becomes serious and serious from year to year. Climate had their own impact on shortage of water and decline of vegetation in the area.

Over the next century, the global population is projected to increase by 50-100% and, likely, there will also be an increase in land use and land cover change at all scales. However, more time series and higher-quality samples need to be shared for high-accuracy cropland or other LULC mapping applications. Explicit and precise information on the reserve extent and location is essential for achieving sustainable development goals and is also fundamental for management.

5. Conclusions

It is undoubtedly that the rapid population growth in rural areas has a great impact on the land use/cover in protected areas. Information on land use and land cover (LULC) including forest cover is important for the development of strategies for land planning and management. The research found a decrease of high and dense vegetation areas into lower and non-vegetated areas within 22 years. It means there is a decrease in vegetation cover due to changes to non-vegetation

cover or land cover areas with less vegetation.

The outcome of the study shows that the policy maker and stakeholder of this region need to be conscious about the rapid development and changes in the land use pattern in the reserve partielle de Dosso. Thus, a major LULC change is identified, and the rapid urbanization and cropland extension are the driving factors to trigger the transformation in the study area during the last two decades. These results contribute to orienting policies for sustainable land management in protected areas.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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