SHORT COMMUNICATION: CAUSES OF SECONDARY FOREST LOSS IN A LOWLAND RAINFOREST OF NIGERIA

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ABSTRACT

The increasing human population which promotes the conversion of secondary forests into other land use types has resulted in the decrease of forest areas in Nigeria. This study examined the causes of secondary forest loss in Osho Forest Reserve, Nigeria. Changes in Land Use Land Cover (LULC) were assessed using Landsat 5 TM and Landsat 8 OLI/TC images for four timelines over a period of 38 years (1984, 2013, 2017 and 2022). Results showed an increase in area of plantations, bare land and farmland, leading to a decrease in secondary forest cover. Farmland increased from 731 ha to 859 ha at the rate of 3.7 ha yr^{-1}, bare land increased from 314 ha to 523 ha at 5.5 ha yr^{-1}, plantations increased from 1,105 ha to 1,495 ha at 10.3 ha yr^{-1}, while secondary forest drastically reduced from 1,132 ha to 405 ha at 19.1 ha yr^{-1}. At this rate, secondary forest is estimated to be lost in the study area by 2050.. Osho Forest Reserve requires immediate management interventions driven by updated laws and policies, silvicultural treatment, community engagement and ecosystem rehabilitation. In addition, implementation of sustainable forest management would enhance secondary forest recovery.

Key words: Osho Forest Reserve, remote sensing, plantation, sustainable forest management, silvicultural intervention

INTRODUCTION

In Nigeria, the forest reservation system was officially created in 1937, when approximately 20–25 per cent of the rainforest was placed under reservation and protected by enactment of gazettes. The aims were to maintain biological diversity, enhance hydrological processes, improve nutrient cycling, control soil erosion, conserve wildlife and improve air and water quality (Olajuyigbe, 2018). These forest reserves are governed by various laws and regulations which include the National Forest Policy, the Forestry Act of 1956 and state-specific forest laws (Edet et al., 2011). These legal frameworks establish rules for activities within forest reserves, emphasising conservation, sustainable management and restricted land use (Enuoh & Bisong, 2015). Forest reserves also contribute to socioeconomic growth and development, providing timber and non-timber forest products (NTFPs).

However, overexploitation of forest resources and land use change have resulted in deforestation and degradation of the reserves. The situation has been exacerbated by weak and outdated forest laws and policies, increased urbanisation and infrastructural development, and population growth. Hence, it is estimated that over 60 per cent of the country's forest estate has been lost to anthropogenic factors (Akpan-Ebe, 2017; Ancha et al., 2021; DeFries et al., 2010). Most forest reserves have become secondary regrowth which are further threatened by pressures from farmland encroachment, urbanisation and tree crop plantation establishment. The loss of secondary forests in the rainforest region of Nigeria would have devastating consequences on flora, fauna and socioeconomic activities of local communities (Fagariba et al., 2018).

Secondary forests, which represent approximately 90 per cent of the tropical forests in West Africa, are natural vegetation, which are recovering mainly through

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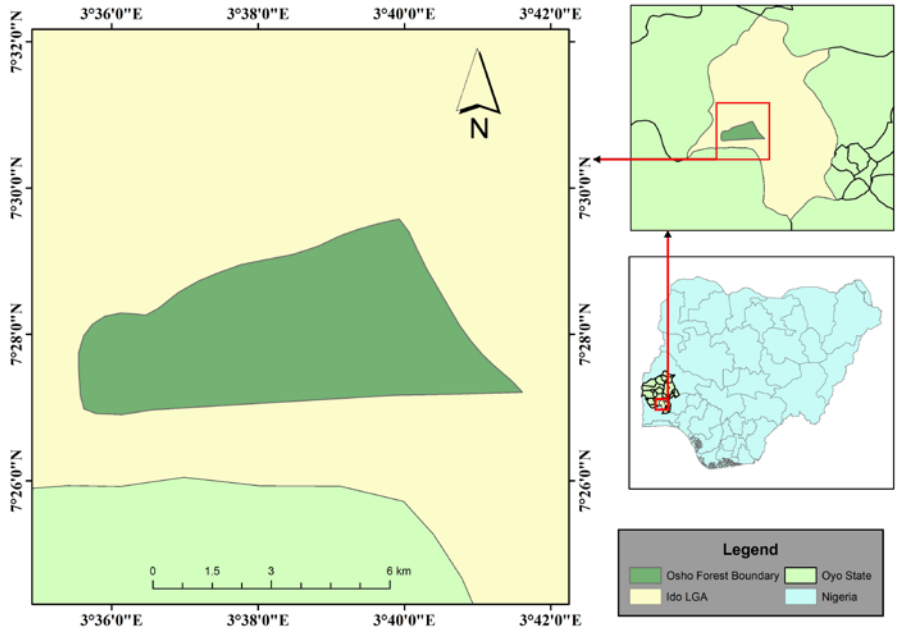

Figure 1. Map of Osho Forest Reserve (inset: maps of Nigeria, Oyo state and Ido local government area)

natural processes, after serious anthropogenic and/or natural disturbances (Chokkalingam & de Jong 2001; Schroeder et al., 2010). Secondary forests provide habitats for plant and animal species, some of which are threatened and endangered. Loss of secondary forest increases the risk of soil erosion, flooding, decreased water quality, and increased sedimentation in rivers and streams (Schroeder et al., 2010; Zeraatpishe et al., 2013). Nevertheless, the conversion of secondary forests to other land uses, such as monoculture plantations and farmlands, is usually seen as a more profitable option than leaving the land in its natural state (Wineman et al., 2021). Hence, large areas of secondary forest are being cleared for non-forest use in the lowland rainforest of Nigeria (Oluwajuwon et al., 2021). This is due to factors such as changes in government policies to promote agricultural expansion, land tenure issues, and lack of enforcement of environmental regulations. In addition, the rapid population growth has increased the pressure on land resources, resulting in increased plantation establishment and encroachment of farmlands into forest reserves (Oyetunji et al., 2020).

Previous studies have shown the increasing levels of conversion of natural forests to other land use types in different parts of the world. For instance, tropical forests were the primary source of new agricultural lands in the 1980s and 1990s, when more than 80 per cent of farmlands were established in the forests (Gibbs et al., 2010). Sanara et al. (2014) showed that farmland expansion was responsible for severe forest loss in Ratanakiri Province, Cambodia. Plantation establishment promoted plant invasions and hindered the survival of endemics in Central Chile and Chilean Patagonia (Andreas et al., 2017) and plantation establishment caused substantial loss of natural forests between 2000 and 2016 in South Central Chile (Altamirano et al., 2020).

Empirical information on the loss of secondary forest cover in comparison to the expansion of other land use types would assist in the development of strategies necessary for their long-term protection and sustainability in Nigeria. In this study, satellite images were used to assess the drivers of secondary forest loss in Osho Forest Reserve, southwest Nigeria.

MATERIALS AND METHODS

Study area

Osho Forest Reserve is one of the major reserves in southwest Nigeria. It is located in Ido Local Government Area of Oyo State, Nigeria (Figure 1). It covers an area of 3,500 ha which was reduced from 5,180 ha, by a 1951 Amendment Order (Azeez et al., 2017; Olayode, 2019). The climate is characterised by two distinct wet seasons, which occur from May to July and September to November, and a major dry season between December and March. The forest contains important indigenous trees such as *Terminalia* spp, *Treculia africana* and *Triplochiton scleroxylon* and exotic species such as *Tectona grandis* and *Gmelina arborea*.

Table 1. Satellite images used in the study

SN	Landsat type	Date	Spatial resolution (m)	Path/row
1	Landsat 5 (TM)	1984	30	191/55
2	Landsat 8 (OLI/TC)	2013	30	191/55
3	Landsat 8 (OLI/TC)	2017	30	191/55
4	Landsat 8 (OLI/TC)	2022	30	191/55

Table 2. Land Use Land Cover classes in Osho Forest Reserve, southwest Nigeria

LULC classes	Description
Secondary forest	Land with vegetation such as trees and shrubs re-growing after natural or anthropogenic disturbances
Plantation	Land dominated by tree stands raised artificially. These include *Tectona grandis, Gmelina arborea, Anogeissus leiocarpus and Tetrapleura tetraptera*
Farmland	Land used for agricultural production including arable crops, permanent crops, pastures and heterogeneous agricultural areas
Bare land	Land not under agricultural use and with no vegetation such as degraded land, bare ground, rocks and quarry-despoiled lands

Table 3. Land Use Land Cover area and rate of change in Osho Forest Reserve, southwest Nigeria (1984–2022)

	1984		2013		2017		2022		
LULC	**Area (ha)**	**(%)**	**Area (ha)**	**(%)**	**Area (ha)**	**(%)**	**Area (ha)**	**(%)**	**Rate (ha yr-1) 1984–2022**
Farmland	731	22.3	987	30.1	1062	32.3	859	26.2	+3.7
Bare land	314	9.8	329	10.0	404	12.3	523	15.9	+5.5
Secondary forest	1132	34.4	1053	32.1	795	24.3	405	12.4	-19.1
Plantation	1105	33.6	914	27.8	1021	31.2	1495	45.5	+10.3

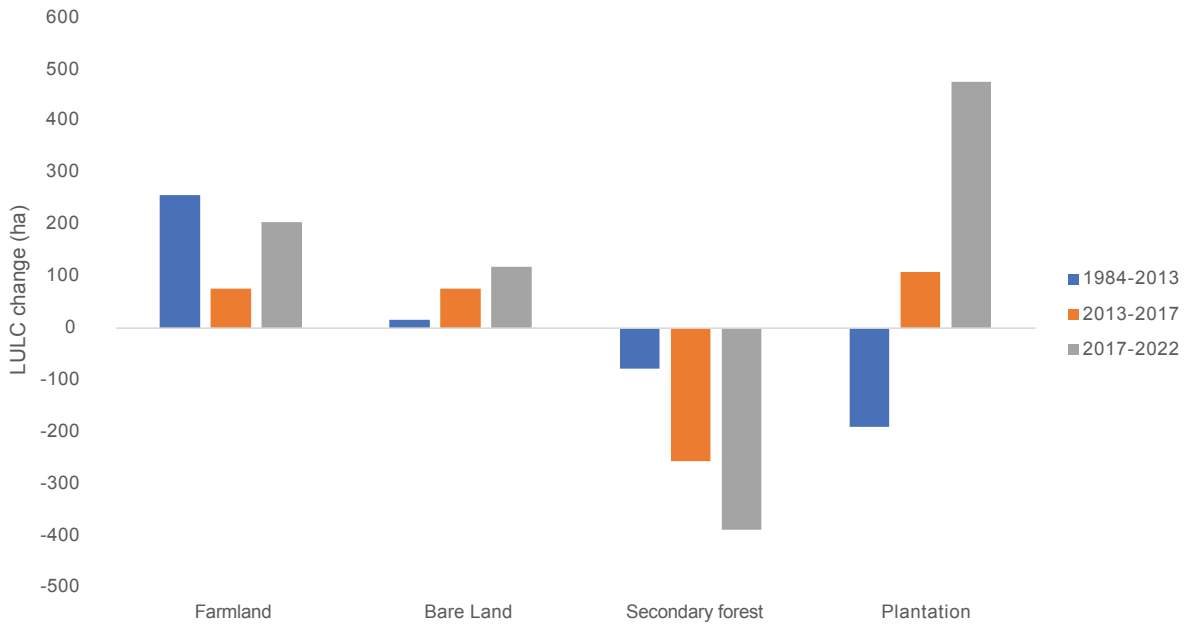

Figure 2. Land Use Land Cover Change between 1984 and 2022 in Osho Forest Reserve, Southwest Nigeria

Satellite imagery

Landsat 5 TM and Landsat 8 OLI/TC were acquired and processed to determine the land use and land-cover changes in Osho Forest Reserve at four timelines over 38 years (1984, 2013, 2017 and 2022) (Table 1).

Trend analysis

The Land Use Land Cover (LULC) was determined using equation1.

$$\Delta LULC = L_2 - L_1 \quad (1)$$

Where L_2 (ha) = Land Use/Land Cover (final year); L_1 (ha) = Land Use/Land Cover (initial year)

Rate of change

The rate of change in LULC was calculated using equation 2.

$$R_{t=}[(L_2 - L_1) \times 1/t)] \times 100 \quad (2)$$

Where L_2 (ha) = Land Use/Land Cover (final year); L_1 (ha) = Land Use/Land Cover (initial year) and t (year) = periodic interval.

Land Use Land Cover classification

Based on the description of Anderson (1976), the LULC classes identified in the study area were secondary forest, plantation, farmland and bare land (Table 2).

RESULTS

The extent and rate of change of LULC classes between 1984 and 2022 are shown in Table 3 and Figure 2. In 1984, farmland covered 731.7 ha (22.3 per cent), bare land covered 314.5 ha (9.6 per cent), plantation covered 1,105.3 ha (33.7 per cent), while secondary forest covered 1,132.2 ha (34.5 per cent). By 2013, farmland had increased to 987.4 ha (30.1 per cent), bare land increased to 329 ha (10 per cent), while secondary forest (1053.3 ha or 32.1 per cent) and plantation (914.0 ha or 27.8 per cent) were reduced in the reserve. However, by 2017, plantation cover increased (1021.7 ha or 31.1 per cent), alongside farmland area (1062.0 ha or 32.3 per cent) and bare land (404.7 ha or 12.3 per cent); while secondary forest (795.2 ha or 24.2 per cent) continued to decline. By 2022, the extent of farmland, bare land and plantation were 859.2 ha (26.2 per cent), 523.1 ha (15.9 per cent) and 1495.5 ha (45.5 per cent), respectively. On the other hand, secondary forest cover had reduced to 405.8 ha (12.4 per cent). Over the 38-year period, farmland, bare land and plantation increased by 3.4 ha yr^{-1}, 5.5 ha yr^{-1} and 10.3 ha yr^{-1}, respectively, while secondary forest decreased by 19.1 ha yr^{-1} (Table 3). Although, there was an initial decrease in plantation area (1984 to 2013), it had the highest positive rate of increase. Secondary forest would be lost entirely by 2050 and largely replaced with plantation forest if the current trend persists.

DISCUSSION

Anthropogenic factors were observed to have severely shifted the reserve from its pristine state, with the LULC classes indicating a disturbed forest ecosystem. Plantation establishment was a primary driver of secondary forest loss. Olajuyigbe (2018) indicated that natural vegetation was being replaced with exotic tree species plantations in an effort to replant the country's degraded rainforest landscape. Similarly, Adeyemi and Ibrahim (2020) found that plantation crops were being established to support timber production, while some forest reserves had become grazing grounds for livestock. This appears to also be the case in Osho Forest Reserve with close to half of the land area presently covered with monocultures of exotic species like *Tectona grandis* and *Gmelina arborea*, and patches of indigenous species plantations of *Anogeissus leiocarpus* and *Tetrapleura tetraptera*. Furthermore, the forest reserve shares boundaries with eight rural communities that depend on forest land for farming activities, wood extraction and charcoal production. The situation is further worsened by obsolete forest laws and policies, inadequate monitoring, and weak technical capacity among forest managers (Olayode, 2019).

Agricultural expansion continues to be implicated as a cause of secondary forest loss in the lowland rainforest region of Nigeria. For example, an increase in farmland area with a corresponding decrease in secondary forest has been reported across southwest Nigeria in Shasha Forest Reserve (Adeyemi & Oyeleye, 2021); Ogbese Forest Reserve (Oluwajuwon et al., 2021); Gambari Forest Reserve (Adedeji et al., 2015); Ijaiye Forest Reserve (Phillips & Ceesay, 2020); Okeluse Forest Reserve (Adeyemi & Olowo, 2022) and Oba Hills Forest Reserve (Adeyemi & Ayinde, 2022). Oyo State is one of the leading agrarian states in Nigeria with approximately 400,000 smallholder farmers (Atser et al., 2019). Hence, the high demand for farmland has led to increased encroachment of forest reserves in the state (Azeez et al., 2017; Haastrup et al., 2020; Oladoye, 2019). In addition, the renewed interest of the state government in agriculture production has led to the degazettment and conversion of parts of forest reserves to large-scale commercial farms.

The expansion of bare lands has serious ecological implications, including habitat loss, land vulnerability to erosion, loss of ecosystem resilience, and decreased ecosystem service provision. The advancement of bare land area threatens the ecological health of the Osho

Farmland Cultivated for Yam in Osho Forest Reserve © Farhan Jimba Moshood

Forest Reserve, as it was observed to increase in size by about 5.5 ha, annually. Bare land expansion has also been observed in forests of the Zurgurma Sector of Kainji Lake National Park (Adeyemi & Ibrahim, 2020) and Andoni LGA, Rivers State Nigeria (Eludoyin et al., 2019).

The future LULC estimates revealed a continuous decline in secondary forest with increases in other land uses, especially plantations. By 2050, secondary forest would have been completely replaced by plantations and other land use types. Similar trends have been reported for other secondary forests in the region. For instance, Phillips and Ceesay (2020) noted that trees in Ijaiye Forest Reserve may last for only 15 years, while Adeyemi and Olowo (2022) estimated that secondary forests in Okeluse Forest Reserve would be completely lost before 2026. Also, Adeyemi and Ayinde (2022) noted that the secondary forests in Oba Hills Forest Reserve may be completely degraded before 2040.

Artificial regeneration through direct tree planting and the taungya agroforestry system are viable alternatives for rehabilitation of forest reserves. Taungya is a system which involves growing annual crops temporarily with trees, during the early phase of plantation establishment. It has been successfully implemented in various reforestation efforts (Appiah et al., 2020; Chamshama et al., 1992). Some of the indigenous and exotic tree species presently in Osho Forest Reserve were established through the taungya system. Azeez et al. (2017) examined the performance of the taungya system in the reserve and affirmed that it contributed positively to the promotion of forest conservation. However, constraints such as lack of technical support, inadequate funding and lack of credit facilities were major impediments to its successful implementation. If these constraints are adequately addressed, assisted natural regeneration and other agroforestry practices may potentially be used to enhance indigenous tree species recovery in Osho Forest Reserve.

The challenges related to ineffective forest management strategies and conflicts between custodians of government forest reserves and farmers have to be addressed. Hence, legal constraints such as limitations on land clearing, farming and commercial activities within and around forest reserves have to be strategically resolved. Interventions such as enhanced law enforcement, community engagement, reforestation and rehabilitation projects, policy reforms, and education and awareness campaigns would be beneficial in achieving ecosystem recovery (Azeez et al., 2010; Phalan & Hajjar, 2007).

The use of remotely sensed data is essential for monitoring trends in LULC change and when combined with sociocultural information helps to identify the drivers of forest cover loss. This information is critical in tropical countries like Nigeria, where deforestation rates are high and secondary forest recovery is vital in initiatives such as landscape restoration and biodiversity conservation (Altamirano et al., 2020).

Teak Plantation in Osho Forest Reserve © Farhan Jimba Moshood

CONCLUSION AND RECOMMENDATION

The forest reserve requires immediate management interventions (such as assisted natural regeneration, enhanced law enforcement, community engagement and rehabilitation) to restore its ecological processes and functions. It is essential to improve land tenure security as this will allow small-scale farmers to practise sustainable land management. In addition, it is essential to build the capacity of forestry officials and communities in strategies that would promote natural forest regeneration as a favourable alternative to plantation establishment in the lowland rainforest of Nigeria.

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RESUMEN

El aumento de la población humana, que promueve la conversión de los bosques secundarios en otros tipos de uso del suelo, ha provocado la disminución de las zonas forestales en Nigeria. Este estudio examinó las causas de la pérdida de bosques secundarios en la Reserva Forestal de Osho, Nigeria. Los cambios en el uso del suelo y la cubierta vegetal (LULC) se evaluaron utilizando imágenes Landsat 5 TM y Landsat 8 OLI/TC en cuatro ocasiones durante un período de 38 años (1984, 2013, 2017 y 2022). Los resultados mostraron un aumento de la superficie de plantaciones, terrenos baldíos y tierras de cultivo, lo que llevó a una disminución de la cubierta forestal secundaria. Las tierras de labranza aumentaron de 731 ha a 859 ha a un ritmo de 3,7 ha/año-1, las tierras desnudas aumentaron de 314 ha a 523 ha a 5,5 ha/año-1, las plantaciones aumentaron de 1.105 ha a 1.495 ha a 10,3 ha/año-1, mientras que el bosque secundario se redujo drásticamente de 1.132 ha a 405 ha a 19,1 ha/año-1. A este ritmo de pérdida, el bosque secundario se habrá perdido en la zona de estudio en 2050. La Reserva Forestal de Osho requiere intervenciones inmediatas de gestión impulsadas por leyes y políticas actualizadas, tratamiento silvícola, compromiso comunitario y rehabilitación del ecosistema. Además, la aplicación de una gestión forestal sostenible mejoraría la recuperación del bosque secundario.

RÉSUMÉ

L'augmentation de la population humaine, qui favorise la conversion des forêts secondaires en d'autres types d'utilisation des sols, a entraîné une diminution des zones forestières au Nigeria. Cette étude a examiné les causes de la disparition des forêts secondaires dans la réserve forestière d'Osho, au Nigeria. Les changements dans l'utilisation des terres (LULC) ont été évalués à l'aide des images Landsat 5 TM et Landsat 8 OLI/TC à quatre reprises sur une période de 38 ans (1984, 2013, 2017 et 2022). Les résultats ont montré une augmentation de la superficie des plantations, des terres nues et des terres agricoles, entraînant une diminution de la couverture forestière secondaire. Les terres agricoles sont passées de 731 ha à 859 ha au rythme de 3,7 ha par an, les terres nues de 314 ha à 523 ha au rythme de 5,5 ha par an, les plantations de 1 105 ha à 1 495 ha au rythme de 10,3 ha par an, tandis que la forêt secondaire a considérablement diminué, passant de 1 132 ha à 405 ha au rythme de 19,1 ha par an. À ce rythme, la forêt secondaire aura disparu de la zone d'étude d'ici 2050. La réserve forestière d'Osho nécessite des interventions de gestion immédiates basées sur des lois et des politiques actualisées, des traitements sylvicoles, l'engagement de la communauté et la réhabilitation de l'écosystème. En outre, la mise en œuvre d'une gestion durable des forêts favoriserait la reconstitution de la forêt secondaire.