



Forest transition in an ecologically important region: Patterns and causes for landscape dynamics in the Niger Delta

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ABSTRACT

The influence of human related activities such as oil and gas exploration, intensified logging of trees and over exploitation of forest resources for food, have negatively impacted the once flourishing and ecologically diverse forest system of the Niger Delta region in Nigeria. Relevant information on the transitional changes of forested landscapes in the delta is poor compared to other tropical forests such as the Brazilian and Columbian Amazonian forest where numerous research studies have been conducted. Consequently, this study aimed at investigating the spatial extent and rates of forest transition in the Niger Delta region taking into consideration the patterns, causes and implications of the landscape dynamics. The study determined the spatial extent and rates of forest transition in the study area using remotely sensed data from 1986 and 2007. The results indicated that the spatial extent of deforestation, unchanged forest cover and afforestation were 1.38, 2.39, and 1.15 million hectares, respectively, while the annual deforestation and afforestation rates were 0.95 and 0.75% which are high compared to other areas in the humid tropics. The annual rate of change in forest cover was determined as -0.13% indicating an overall reduction in the spatial extent of forest cover for the entire delta. Changes in the spatial structure of forests were investigated using landscape metrics and the results showed there was a substantial increase in forest fragmentation. The variations in population dynamics and poverty indicators between different states of the Niger Delta were unable to explain the observed patterns of forest change. Instead, the authors observed that the main determinants of forest dynamics were the variations in state forest management policies and the influence of the oil and gas industry on the economies of the states. High rates of afforestation were found in states that have limited oil resources and were more economically dependent on forest products, while states with high deforestation rates were found in the main oil-producing parts of the study site. Using the present trend of forest transition dynamics, a 20-year forward simulation was generated using the Markov algorithm. The results concerning forest transition in the study area point to the urgent need for appropriate environmental policy development and implementation for the Niger Delta region.

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1. Introduction

The fragile mosaic of aquatic, wetland and terrestrial ecosystems of the Niger Delta region in Nigeria is faced with a diverse range of environmental problems resulting from factors such as agricultural land degradation with consequent soil erosion and flooding; shoreline development; changes in local hydrology resulting from sea level rise; pollution from the oil industry, pipeline construction and seismic activities; over exploitation of forest resources for food and construction, illegal felling of trees, agricultural activities and rapid urbanisation (Moffat and Linden, 1995; NDES, 1997; Wang et al., 2005). In particular, deforestation is a major threat affect-

ing the natural ecological status and biodiversity of the region, as well as the human population that depends upon resources and services provided by the ecosystems of the delta for their livelihood. The economically viable resources derivable from the Niger Delta forest landscape can be classified into timber and non-timber forest resources. Some of the major timber resources derivable from the forests of the Niger Delta are saw-logs, chewing sticks, transmission poles, building and furniture wood/poles, and fuel wood which are obtained from the mangroves, rain forest areas, coastal ridges and fresh water swamps, all of which are being over exploited (NDES, 1997). The non-timber resources are derivable from oil palms, raffia palm, bush mangoes ("ogono"), food spices, medicinal roots and leaves, giant snails and many others. The production of oil from the raffia palms is a huge source of revenue in some states such as Delta and Rivers which are the highest producers (NDES, 1997). It has been recognized for some time that

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deforestation is a large-scale problem in the freshwater swamps and barrier island forests of the Niger Delta region with an estimated 5–10% of primary mangrove forests having been lost (Moffat and Linden, 1995). Much of the deforestation has been attributed to urban growth and intensified human activities such as logging and the expansion of agriculture (Moffat and Linden, 1995; NDES, 1997). In the pre-colonial and colonial periods the great demand of tropical hardwoods by Europe heralded the threat of deforestation in the Niger Delta region of Nigeria. This led to the introduction of intensive lumbering activities and tree crop exportation from the lowland forests of the Niger Delta to Europe (Areola, 2001). The rapid increase in the over exploitation of these forest resources increased as timber export and plywood companies came into the heart of the then Bendel state (now known as Delta and Edo states) of the Niger Delta. This was done in order to facilitate the harvesting of timber from forests in Benin, Edo state and Sapele, Delta state. Development activities like road construction, urban expansion and establishment of industries resulted in the once fertile and flourishing lowland forest becoming an over-exploited region with most of the forest resources lost to intensified human activity (Moffat and Linden, 1995).

At present, information concerning the current rates of deforestation for the region is lacking, as, indeed, is knowledge of the rates and patterns of afforestation. The Federal Department of Forestry (FDF), which has the responsibility of coordinating forestry related issues in Nigeria, has embarked on a number of nationwide studies in the past through the Forestry Management, Evaluation and Coordinating Unit. Over the last three decades projects have been executed to determine the state of the country's forests, producing information on land-use and vegetation cover from a variety of sources. Such studies have demonstrated that deforestation has been particularly prevalent in the types of forests such as mangroves, swamps and riparian forests that dominate the Niger Delta (Areola, 2001; Olaleye and Ameh, 1999; Treveet, 1979). However, Areola (2001) observed that the major problems facing the FDF were the absence of up-to-date information on the state of forests in the country and lack of a properly coordinated system to manage such information, hence resulting in information being distributed across different organisations in the country. Similarly, Olaleye and Ameh (1999) identified limited coverage of forest inventories and the absence of up-to-date information across states in Nigeria as major problems facing the government in determining the country's current status of forest changes.

The Niger Delta region is faced with the difficulty of inaccessibility during ground surveys thus making most parts of the region unreachable due to the dense forest cover and difficult undulating terrain. Moreover, the volatile communities present in many parts of the Niger Delta can compromise the personal safety of non-indigenes and prevent *in situ* surveys. In such circumstances, the use of remotely sensed data offers numerous advantages for providing forest related information across the study area. Furthermore, the possibility of repeated image acquisitions over long periods of time and with a synoptic view covering large spatial areas, provides a means of monitoring forest dynamics across the entire Niger Delta. Indeed, this has been demonstrated to some extent in a study conducted by Godstime et al. (2007) where Landsat satellite imagery covering the Niger Delta was used to map the spatial extent of mangrove loss in the region. The study also identified as the primary cause of deforestation urbanisation, dredging activities, oil exploration and the spread of the invasive *Nypa Palm*.

Deforestation can lead to intensified fragmentation resulting in the reduction of forest patches and increased isolation. Studies aimed at quantifying the nature and consequences of forest fragmentation have been conducted and vital results obtained. For example, it has been found that the tropical forests of the Amazon are subject to accelerating deforestation rates resulting in forest

fragmentation and changing patterns of ecosystem loss (Laurance et al., 2000; Lima and Gascon, 1999). The study of Armenteras et al. (2006) on the Colombian Amazon examined the pattern of ecosystem diversity, deforestation and fragmentation through the temporal and spatial analysis of biotic and abiotic data using remote sensing and geographic information system. The pattern of deforestation and annual rates of deforestation for different parts of the region were investigated. The annual deforestation rates were 3.73 and 0.97% in two areas with high human population densities while for relatively unpopulated areas the rates were 0.31, 0.23, and 0.01%. At present similar information on the level of forest transition and forest landscape fragmentation is lacking for the Niger Delta.

The aim of this study was to investigate rates of forest transition in the Niger Delta region taking into consideration the patterns, causes and implications of landscape dynamics in the delta. The objectives were as follows:

- i. to determine the spatial extent and rates of deforestation, afforestation and forest change in the Niger Delta using remotely sensed imagery,
- ii. to investigate the effects of forest transition on the spatial structure of forest landscapes in the Niger Delta,
- iii. to examine the extent to which socio-economic factors influence the processes of forest transition, and
- iv. to simulate likely future changes in forest cover of the Niger Delta.

2. Materials and methods

2.1. Study area

The study area was the Niger Delta (Fig. 1). Geographically the Niger Delta is taken to have its apex at Aboh 5°33'49"N, 6°31'38"E which bifurcates into two main distributaries, the Nun and Forcados. The southernmost tip of the Delta is at Palm Point (4°16'22"N, 6°05'27"E) south of Akassa and at the estuary of Nun River. The Niger Delta region extends from the Benin river estuary (5°44'11"N, 5°03'49"E) in the west to the Imo river estuary (4°27'16"N, 7°35'27"E) in the east and has a total land area of approximately 25,900 km² or approximately 2.8% of Nigeria's total land area (NDES, 1997). The natural vegetation of the Niger Delta is classified into five types which are as follows: moist lowland rainforests covering the upper riverine floodplains and Sombreiro-Warri plains; freshwater swamp forest covering the lower riverine floodplains and along the river valleys; the mangrove zone comprising the mangrove forests and mangrove swamps located in the upper tidal and lower tidal zones, respectively; saltmarsh and tidal mudflats along the shorelines; and coastal forests and thickets on the barrier sand ridges (NDES, 1997). In the Niger Delta population distribution and settlement pattern are determined by the availability of dry land within the mangrove swamp dominated zone. Most of the Niger Delta is characterized by massive and continuous swamps dotted by islands of dry land. Due to the narrow fringe-like islands dominant in the region land reclamation (through sand filling) is a common practice in order to accommodate the growing population (Moffat and Linden, 1995). Consequently, the largest settlements of the Niger Delta are locations further away from the mangroves such as Benin, Sapele, Warri, Port Harcourt and Ughelli (NDES, 1997).

2.2. Mapping deforestation and afforestation

For this study the analysis of remotely sensed data was undertaken in four stages namely: data acquisition and

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