Understanding changes in a Tropical Delta: A multi-method narrative of landuse/landcover change in the Niger Delta

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ABSTRACT

Increasing demand for land resources by a rapidly growing population, with fast urbanization and industrialization, has resulted in landuse changes all over the world. This study evaluates landuse models used in literature to explain environmental change against the drivers of landuse change, using Niger Delta of Nigeria as a case study. The remote sensing and social survey data were used to examine spatiotemporal change in landuse in the Delta. The landuse change detection analyses were carried out using the Normalized Difference Vegetation Index (NDVI) and classification methods. The results show severe deforestation, especially in Northwestern and Northeastern parts of the delta. This is evident from the mean NDVI, which decreases from 0.61 in 1987, to 0.55 in 2001, and decreases further to 0.48 in 2011. The majority of local people in Okomu, Tsekelewu, Eket and Oboolo perceived expansion in urban areas (95.54%, 87.34%, 93.12% and 88.54% respectively) and farmland (91.87%; 80.01%; 85.71% and 87.53% respectively), while forest decreased (98.40%; 87.70%; 86.70% and 90.26% respectively) over the last twenty-five years. The study concludes that the drivers of landuse change in the Niger Delta are complex, and that there is the need for proper implementation of forest policies and enforcement of the existing environmental laws as the best options to eradicate deforestation in the Niger Delta.

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1. Introduction

Understanding the impacts and drivers of global landuse change has been a major concern for scientists over several decades. Both regional and local studies have shown that in the last few decades, the impacts of landuse change have increasingly assumed significant to threatening proportions. For example, some of these studies have noted that conversion of cropland and forest lands into urban uses is one of the important types of landuse change in the tropical country because of its socio-economic and environmental implications (Lambin et al., 2003b; Meyfroidt et al., 2013; Romijn et al., 2015; Geist and Lambin, 2001). The landuse change assessment is important because it is human activities (different uses of land), not nature's agents, that bring about these environmental changes, and is responsible for their magnitude and severity (Lambin et al., 2001; Foody, 2003).

In Nigeria, landuse change has become a matter of public, political and academic concern over the past few decades. During the past few decades, change in landuse and forest degradation have been the foremost environmental problem confronting the Niger Delta of Nigeria (Ayanlade, 2015). These environmental problems have led to losses of biodiversity, arable land, lives, and properties. Landuse change in the Delta is a critical issue, though political and economic issues take center stage in national subject matter nowadays, and environmental degradation in the region is not gaining considerable attention. Hence, demands for land resources has increased greatly by fast-growing population. Unfortunately, these resources are exploited without efficient management (Ayanlade and Drake, 2016; Kuenzer et al., 2014). In general, the majority of previous studies have revealed that extraction of oil has been a major factor of deforestation, biodiversity loss; destruction of land resources and landuse conflict in the Niger Delta (Mmom and Arokoyu, 2010; Gerhart, 2001). Other studies have found that the issues of land conflict in the Delta are the result of changes in landuse in the region (Onojeghuo and Blackburn, 2011; Ugoh and Ukpere, 2012; Enaruvbe and Atafo, 2016). These imply that landuse problem in the Niger Delta is a complex problem, and the drivers are beyond oil exploration alone, but more as a result of the unsustainable use of land resources. In spite of the impacts of oil exploration

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activities and production infrastructures in the region, vast defor-estation results from commercial logging, firewood collection by local people, clearing of the forest for agricultural purposes, and urban encroachment on farmland/forest constitute serious envi-ronmental problems in the Niger Delta.

Even with these environmental challenges, little research has been conducted in term of assessing the rate of occurrence, types, and drivers of environmental change and examining social impli-cations of the change in the Niger Delta. One of the reasons for this may be due to lack of accurate data and insecurity, which are militating against qualitative research work and appropriate deci-sion making, in respect to environmental problems in the region. Therefore, this study attempts to use remote sensing to quantita-tively examine spatiotemporal changes and drivers of landuse in the Niger Delta. Remote sensing method is employed in this study because it is a fast method of acquiring up-to-date information over unsecured geographical area like the Niger Delta. Also, remote sensing offers a variety of benefits compared to other forms of data acquisition. Data from satellite imagery are not biased, unlike other means of data collection in which human irregularities and uncertainties are predominant. Using remote sensing techniques in this research, it is possible to measure occurrence and rate of environmental change in the Niger Delta without being affected by insecurity anxiety in the region.

2. Materials and methods

2.1. Conceptual models explaining drivers of landuse change in the Niger Delta

Several models have been used in literature to explain factors of landuse change both at regional and local levels (Lambin et al., 2001; Geist and Lambin, 2001; Verburg, 2006; Matthews et al., 2007; De Rosa et al., 2016). In Niger Delta, a significant amount of literature has documented the dynamics of landuse with diverse views. For instance, Onojeghuo and Blackburn (2011), Ayanlade (2015), Enaruvbe and Atafo (2016) examined landuse changes in the region and showed almost complete absence of primary forests in the region. They concluded that drivers of landuse change were principally from rapid urbanization, agricultural expansion, defor-estation and degradation of mangrove, especially from petroleum activities. They also suggested that there are patches of primary forest remaining, particularly at the centre and southwestern part of the zone; mostly around Gilli-Gilli forest reserve.

From abundant and sometimes contradictory conceptions of environmental change examined in the literature, this section introduces the conceptual model that underlies this study. Broadly speaking, three major concepts explain the drivers of landuse change in the literature: proximate, underlying and other drivers. Proximate drivers of landuse can be interpreted as the direct factors which drive environmental change, and subsequently have direct impacts on the rate of landuse change in a region (Lambin et al., 2001; Geist and Lambin, 2001; Serneels and Lambin, 2001; Meyfroidt et al., 2013; Qasim et al., 2013). Examples of proximate factors are agricultural activities, wood extraction, and infrastructural expansion. On the other hand, underlying drivers are fundamental forces that strengthen more obvious proximate causes. Underlying factors include such drivers as complex socioeconomic, demographic, cultural, technological and political influences that create initial conditions in the human-environmental relationship. Other drivers of landuse include predisposing environmental factors (e.g. soil types and processes), social trigger events (e.g. social disorder and war), and biophysical drivers (e.g. ecological succession, weather and climate variations), which enhance rapid change in the landuse in some areas, but not others.

Geist and Lambin (2001) and Qasim et al. (2013) examined fur-ther the conceptual models to explain the causes outlined above in relation to forest loss. The model was based on the subnational case study evidence of deforestation, with the main research ques-tion focusing on "what drives deforestation?" Proximate drivers of landuse change, according to this model include immediate and local factors that have direct impacts on landuse pattern. The most important proximate factors of landuse change in the tropical region are agricultural expansions, wood extraction and infrastruc-ture extension (Geist and Lambin, 2002). The underlying drivers may include indirect impacts of national demographic and socioe-conomic factors (e.g. national economic development) or the direct impacts at the local level, such as local population density (Qasim et al., 2013, Geist and Lambin, 2002, 2001). The categories of "other factors" in the model compose of biophysical drivers, predisposing environmental factors, and social trigger events (Iwamura et al., 2016; Plieninger et al., 2016; Ricaurte et al., 2017). However, the conceptual models consider the complexity of many drivers of the landuse, ranging from socioeconomic to biophysical drivers; and
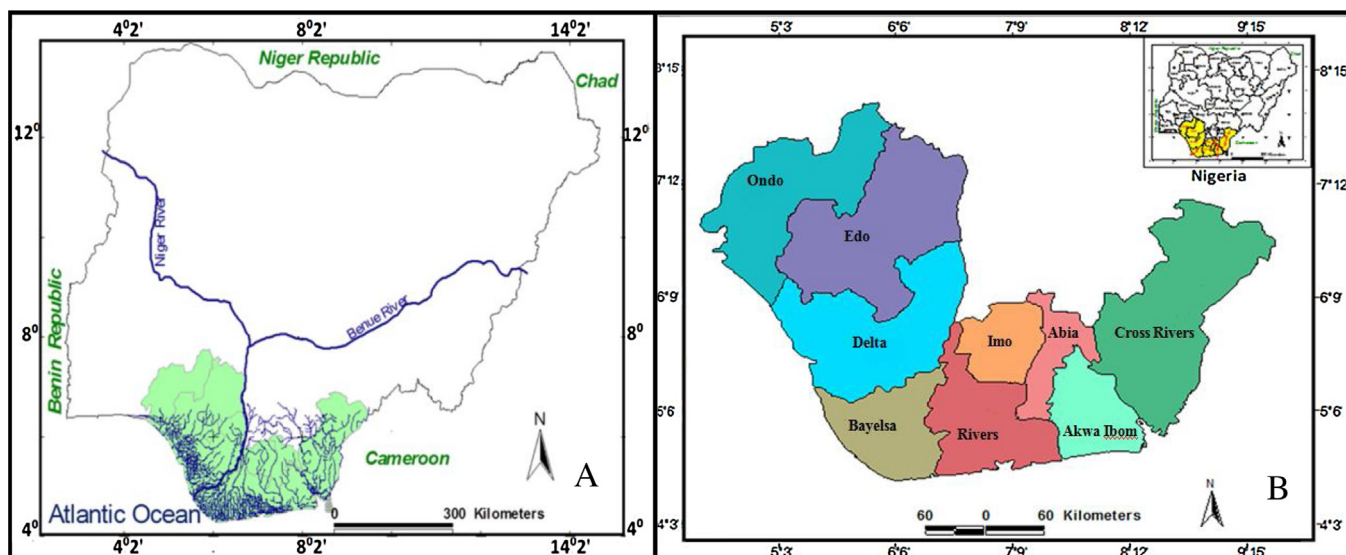

Fig. 1. Map of the Niger Delta. *A* is the map showing the Niger and Benue Rivers, *B* illustrates the location of nine states within the region.