Predicting Changes in Landuse and Landcover in Niger Delta using Post Classification Analysis.

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Abstract
Post Classification sorting was used to extract average spectral response of land cover classes in class boundaries between two images of 1996 and 2010 to generate land use change. A Landuse change extracted from cross-tabulation of classified clusters was observed in about 30,213 hectares in this scene area. Compared with the approximately 1.4 million hectares of land in the scene, a change of about 2.2% in classes of features between 1996 and 2010 were evident. Highly significant change was evident in the change from Scrub/Shrub in 1996 to Forest-Lowland swamp in 2010 which accounted for 31% of the change occurring in this scene. Landuse accounting from remote sensing and GIS can help planners integrate various uses of land for urbanization, industralisation or agriculture.
Keywords: Post Classification sorting, Change detection, Landuse-Landcover, Landuse change

1.0 Introduction

The diverse areas of land cover in the Niger Delta are currently undergoing complex transformations ranging from conversion for residential and commercial purposes to industrial, recreational and agricultural purposes. These rates and amount of changes can be monitored using remotely sensed data in combination with ground survey, either by photo interpretation of enhanced false-colour composite imagery from different dates or by digital analysis of the imagery using change detection techniques (Quarmby 1989). For proper land management decisions to be made from a policy perspective, it is important to understand interactions between human activities and components of the natural landscape.

Several techniques for determining land cover change include post classification analysis (Hurd *et al.*, 1992), multidate classification change detection, cross-correlation analysis and multidate principal components analysis and RGB-NDVI color composite change detection (Hurd *et al.*, 2001). Many authors (Augenstein et al 1991, Ferguson et Al 1993, Jensen et al 1995,) have also used post classification analysis to produce effective maps of changes as long as the individual maps are classified as accurately as possible. In this paper Post Classification Analysis is used to study land use changes occurring in an area of Niger Delta in Southern Nigeria. Satellite Imagery of a historic landcover database and another single-date, multispectral image have been used to qualitatively and quantitatively identify the nature and types of landcover change over this area of the Niger Delta.

2.0 Study area

The study area is located on the central eastern coastal area in Nigeria (fig 1). The area under study has eight coastal river mouths with land cover dominated by tall mangroves, peat flats, freshwater forest banks, and regrowth communities. Numerous oil and gas activities found as features are represented as flow stations, pipelines, and well heads. Interspersed with oil and gas features are numerous communities, some indigenous and others migrant communities with fishing as their mainstay.

Beyond the riverine areas on the image are many urban centers of Political and commercial importance. The Landsat ETM imagery is orthorectified to UTM, Zone 42, WGS84. The coordinates of the study area in UTMs will be UR 433473.87, 559210.70, LR 393950.64, 376977.85; UL 249821.03, 585717.3; LL 209824.47, 402301.12, resulting in a study area that is 1,800 km wide (east/west) by 1,500 km high (north/south).

Fig 1.0 Map of Nigeria with area of analysis depicted by the rectangle

3.0 Materials and Methods

3.1 Landuse-Lancover Classification

The imagery scenes used were archived Landsat 5 TM from December 1996 and Landsat 7 ETM+ (Extended Thematic Mapper) from December 2010. To derive data sets for change detection a landuse-landcover classification was performed using ERDAS Imagine software. The raw TM scene was imported into ERDAS Imagine 9.0 and converted into image files. An unsupervised classification was performed using the ISODATA algorithm technique to classify the image into clusters and to identify potential change classes (change and no change clusters). The ISODATA iteratively groups pixels based on their spectral similarity or differences. At completion of iteration, landuse-landcover was assigned to 12 classes classification scheme (Table 1) based on photo-interpretative technique and knowledge of the area from ground truth. The landcover categories follow closely to those defined by Anderson et al. (1976). The resulting classified image of the clustering was displayed and examined in order to determine the land covers which corresponded to each cluster for both dates.

Table 1.0 Land use-Land cover classes

1		Forest, Rubber
2		Forest, Lowland/Swamp
3		Scrub/Shrub
4		Grassland
5		Barren/Sparsely Vegetated
6		Man-made/Built-up
7		Agriculture-Crop
8		Agriculture - Rice
9		Wetland-Tall Mangrove
10		Wetland-Short Mangrove
11		Water
12		Cloud

3.2 Change Detection Framework Technique

A post-classification analysis procedure was carried out using supervised classification after ground-truthing of the image scene area. Classified images of 1996 and 2010 were then overlaid in order to generate a change image. An analysis of from-to-class change was performed between the two land cover classifications. This allowed for analysis of the data to determine what types of land cover were being lost or gained, and what issues related to those categories are occurring in the study area over 14 years.

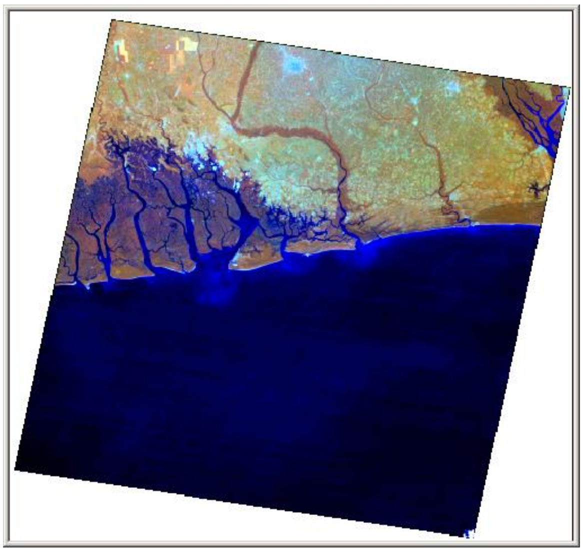

Figure 2a. Landsat 5 TM, December 1996, RGB 4,5,3

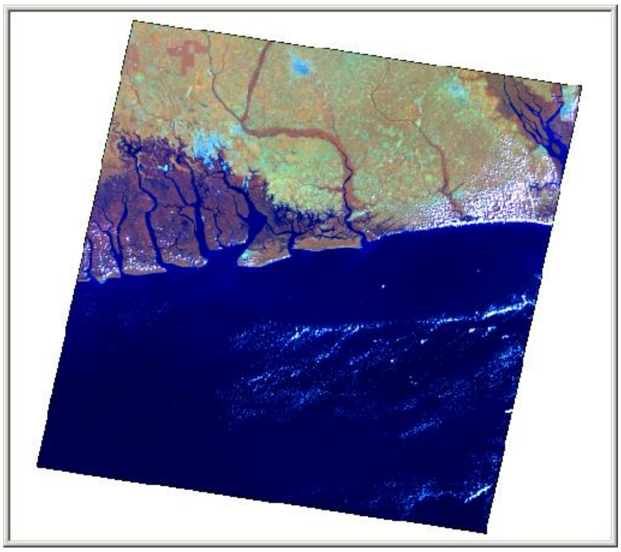

Figure 2b. Landsat 7 ETM+, December 2010, RGB 4,5,3

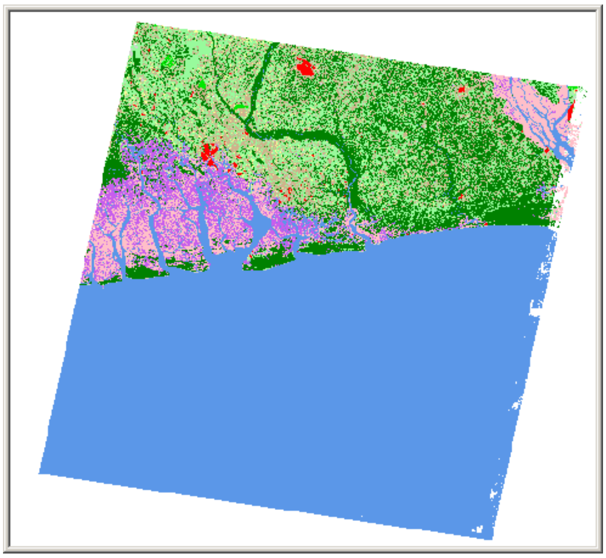

Figure 3a. Landuse and Landcover Classification of Landsat 5 from December 1996.

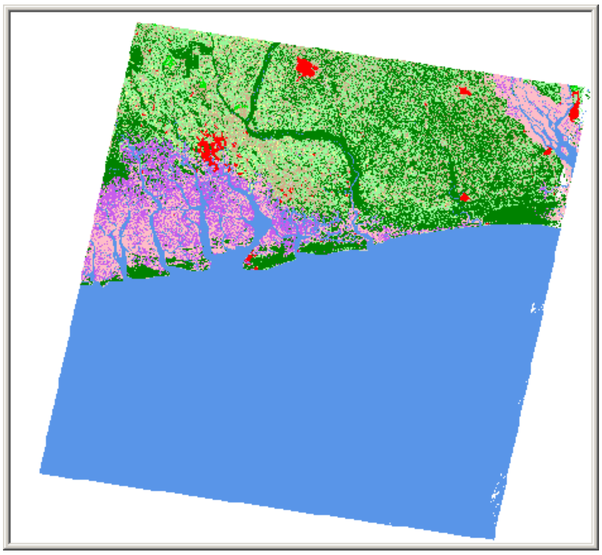

Figure 3b. Landuse and Landcover Classification Landsat 7 from December 2010.

4.0 Results

The change detection analyses for the multi date imagery of 1996 and 2010 are shown in Table 2.0. Table 2.0 shows the change matrix defined into two classes of (i) conversion-from and (ii) conversion-to. The percentages in the cells reflect the overall change from-to class changes between 1996 and 2010. The rows represent the classification from 1996 and the columns are from 2010. The matrix shows that two categories namely Forest-Rubber and Manmade were not converted to any other landcover or landuse category between 1996 and 2010.

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Table 2.0 Change Matrix Between 1996 and 2010 for Land Cover types by Percent

1996 \ 2010	Forest - Rubber	Forest – Lowland/Swamp	Scrub/Shrub	Grassland	Barren/Sparsely Vegetated	Man-Made,	Agriculture - Other	Agriculture - Rice	Wetlands/Tall Mangrove	Wetlands – Short-Mangrove	Water	Cloud	Totals
Forest - Rubber	–	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Forest – Lowland/Swamp	0%	–	2%	0%	1%	2%	1%	0%	0%	0%	1%	0%	7%
Scrub/Shrub	0%	31%	–	0%	0%	8%	0%	0%	0%	0%	0%	0%	39%
Grassland	0%	0%	1%	–	0%	3%	0%	0%	0%	0%	0%	0%	4%
Barren/Sparsely Vegetated	0%	3%	0%	0%	–	4%	0%	0%	0%	0%	2%	0%	9%
Man-Made	0%	0%	0%	0%	0%	–	0%	0%	0%	0%	0%	0%	0%
Agriculture - Other	0%	1%	4%	0%	0%	13%	–	0%	0%	0%	0%	0%	18%
Agriculture - Rice	0%	0%	0%	0%	0%	0%	0%	–	0%	0%	0%	0%	0%
Wetlands/Tall Mangrove	0%	0%	0%	0%	1%	1%	0%	0%	–	0%	9%	0%	11%
Wetlands – Short Mangrove	0%	0%	0%	0%	0%	0%	0%	0%	0%	–	3%	0%	3%
Water	0%	2%	1%	0%	2%	0%	0%	0%	2%	0%	–	0%	7%
Cloud	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	–	0%
Totals	0%	37%	8%	0%	4%	31%	1%	0%	2%	0%	15%	0%	30213

Major Moderate Minor

The number of conversion from one category to another is illustrated in Fig 4. The highest conversion-from-to another category occurred in the forest-lowland in 5 classes. This category is the bushy natural indigenous land cover often the victim to the development of any other land use. This is followed by the water category which was converted into other classes 4 times. The wetland/tall mangrove, agriculture and the barren/sparsely vegetated were converted into three other classes. The least is in the short mangrove class which was converted into only one class. These number of conversion shows that the susceptibility of the forest-lowland landcover to undergo change is high.

In the conversion-to-from category the man-made class received converted landcover from 6 classes. Three other classes, scrub-shrub, the forest-lowland swamp and water received each converted landcover from 4 classes. Only the wetland-tall mangrove class received converted landcover from one (1) class. From these number of landcover classes that contribute to another landcover type, the manmade landuse class has the highest significant influence on observed changes.

Table 3.0 Landcover-Landuse Hectares Loss-Gain between 1996 and 2010

Landuse-Landcover	Loss-Hectares	Gain-Hectares
Forest - Rubber	0.00	0.00
Forest – Lowland/Swamp	2417.04	11178.81
Scrub/Shrub	12085.20	2417.04
Grassland	1208.52	302.13
Barren/Sparsely Vegetated	2719.17	1208.52
Man-Made	0.00	9063.90
Agriculture - Other	5438.34	302.13
Agriculture - Rice	0.00	0.00
Wetlands/Tall Mangrove	3323.43	1208.52
Wetlands – Short Mangrove	1208.52	302.13
Water	2417.04	4531.95
Cloud	0.00	0.00

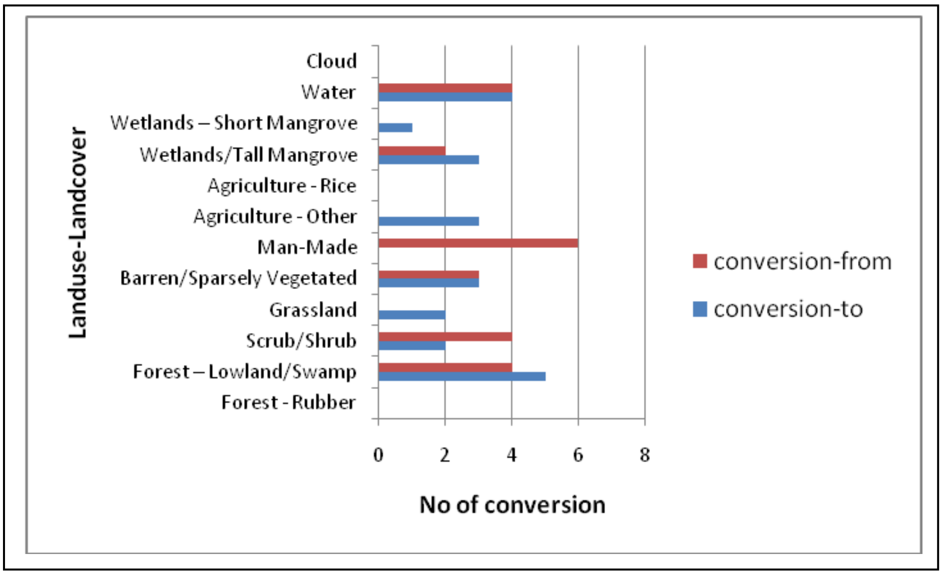

Fig 4.0 Number of landover conversions.

A loss and gain analysis illustrated in Fig 5 shows the highest percentage of loss-gain to be between the Scrub/Shrub and the lowland-forest category between 1996 and 2010. Both categories account for between 35-45% changes that occurred in this scene. For the shrub/scrub observed conversion, the type of change seems to suggest that clear-cut vegetation grew into lowland forests during the process of reforestation. The observed change as is illustrated in Figures 5a and 5b is rather due to the conversion of the scrub/shrub areas in 1996 into healthy Palm trees within the plantation by the year 2010 accounting for a total gain of about 11,000 hectares (table 3.0).

The second most significant change between the years of 1996 and 2010 is from agriculture to man-made (urban development). This accounted for about 13% of the change in this study area. This change took place mainly near the city of Port Harcourt, which is a coastal city, involved in the shipping and processing of oil. This change is mainly due to the use of agricultural land for suburban development on the outskirts of the cities. Scrub/Shrub was also converted to suburban use at a high rate of 8%. Thus the man-made category increased from 1996 to 2010 by 9,063 hectares. This accounts for 31% of the change overall. This is plausibly due to the rapid increase in population and expansion of the oil industry activities. Some other classes impacted by this increase in development are Barren/Sparsely Vegetated (4%), Grassland (3%), Forest (2%), and Wetland/Tall Mangrove (1%). The tall mangrove areas being converted are also products of reclamation activities encouraged to acquire land either for oil and gas establishment as in and around the city of Port Harcourt or for expanding opportunities for modern community housing schemes.

The third most significant change is the converting of tall mangrove (9%) and short mangrove (3%) wetlands to water. This is plausibly due to a number of factors which include dredging and channel deepening activities, erosion and bank collapse of peat (chikoko) and subsidence resulting in increased inundation of intertidal areas by increased tidal flux.

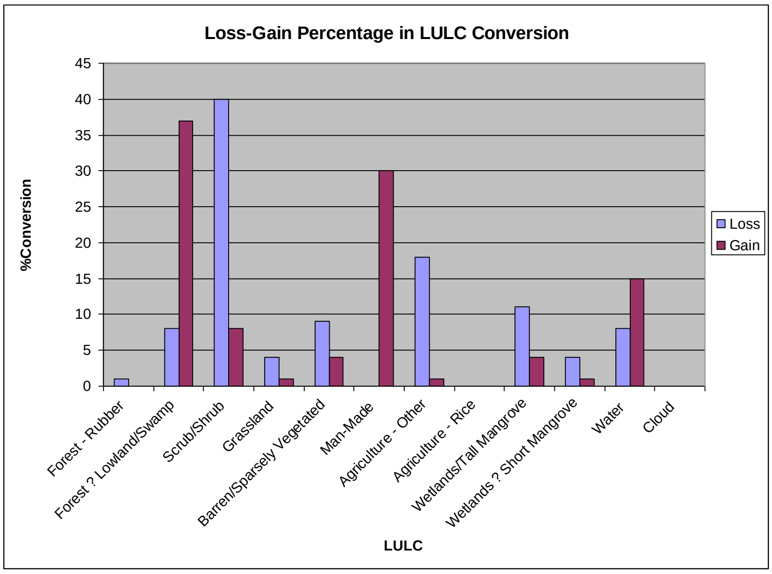

Fig 5.0 Percentage Loss-Gain of Landcover types

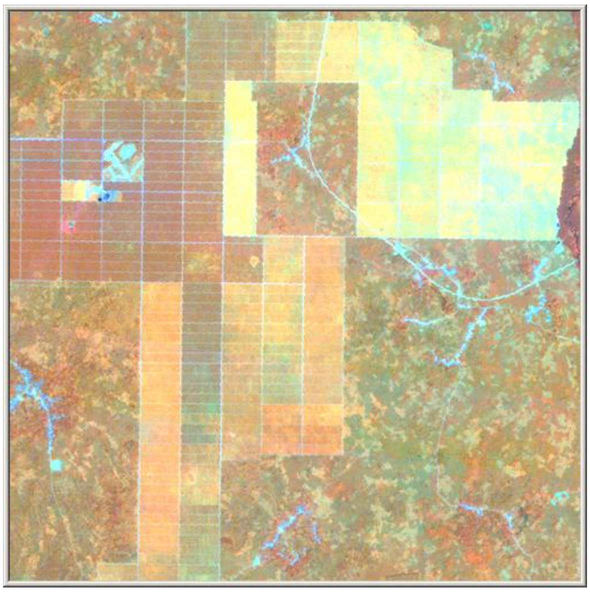

Figure 5a. Palm tree plantation Landsat 5 TM, December 1996, RGB 4,5,3

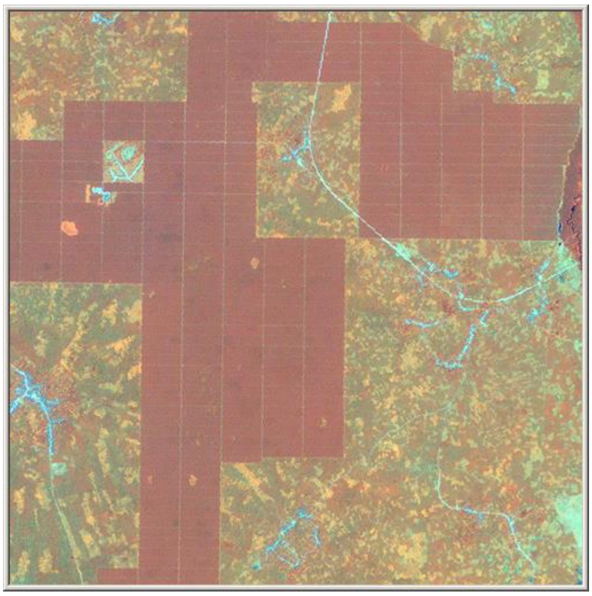

Figure 5b. Palm tree plantation in Landsat 7 ETM+, December 2010, RGB 4,5,3

5.0 Discussion

The change analysis indicates that a total of 30,515 hectares of change occurred in this scene area. Compared to 1.4 million hectares of land contained in this scene, a 2.2% change in classes of features therefore occurred between 1996 and 2010 giving a mean annual rate of 0.2% change in land cover. This rate is evidently dominated by man-made more than anthropogenic factors. Man-made events to service development of industries and residential needs in the urban areas and agriculture illustrated by the Palm Plantation significantly drive the change in contrast to anthropogenic events such as observed in changes in coastal geomorphology. These man made induced changes would continue to be an increasingly important issue because changes in this scene are tightly coupled with the positive benefits of economic growth and development linked to increasing oil and gas activity. The competing interests generated by various alternatives of land use provide a need for access to basic information and tools required to make informed decisions translated through tradeoff mechanisms.

Land use in general is a complex issue. Understanding, documenting and managing it in the Niger Delta suffers from the lack of quantitative and analytical tools for assessment, planning, or evaluation of policy alternatives. Specifically, only modest, if not feeble, capabilities exist in local and state planning authorities to make policies and credible forecasts of land use change in order to evaluate the efficacy of various options as they play out into the future. With the defunct Nigeria Satellite (Nig-Sat), it would have been possible to have good data and analytical tools to plan future scenarios. The French SPOT however can still provide planners and policy makers now with this satellite technology and knowledge-based tools to making critical decisions that affect biodiversity, conservation, green businesses and land management in general.

The paper provides the scope for the decision-making process to begin to incorporate most of the factors which define and drive landuse changes, including transportation infrastructure, population growth and distribution, oil and gas investment and distribution, location of natural resource-based industries, including agriculture, forestry, and tourism, commercial and residential development, land values which change with sprawl and development, and changes in the landscape and environment.

All these factors should be considered and translated through an approach that focuses on the development of a decision support system. The decision support system using existing new technologies, tools, and methods would prioritize and provide specific focus for dataset development and information gathering. Land use changes can then be placed within a forecasting service with time, scale and accuracy coupled with other planning efforts such as economic development which provide opportunities to integrate demographic, social, and environmental elements.

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