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LANDUSE/LANDCOVER PREDICTION USING REMOTE SENSING DATA AND LAND CHANGE MODELER (LCM) IN BANIKOARA DISTRICT, BENIN

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ABSTRACT

The landuse/landcoverchange has important role in environmental changes. This study aims toanalyze the trend inlanduseand landcover(LULC) changesand simulate these changes by the horizon 2025 and 2050.The methodology isbased on Landsat ETM+ and Landsat OLI-TIRS image segmentation after color composite using PIR, Red and Green bands (543 for OLI-TIRS and 432 for ETM+) and supervised classification using IDRISI Selva. The module LCM of IDRISI Selva was also used for landuseand landcoverprediction. The LCM is based on Markov chain. The result reveals that in 2000 and 2013, the savannah and light forest considerably decrease in profit of farm and fallow land and this tendency will continue to 2050. The dense and gallery forest decrease also between 2000 and 2013 but they will increase between 2013 and 2050. That is justified by the presence of protected area.

KEYWORDS: LULC, Land Change Modeler, Banikoara

INTRODUCTION

Landuse and landcoverdynamics have an important role in economic planning and social development. The economy of many developing countries relies largely on renewable natural resources which have been regarded for a long time as gifts of nature. Today, forest resources are being depleted at an alarming rate as a result of severe exploitation (Mama, 2002). The landuse/landcoverchange has important role in environmental changes. It contributes significantly to the earth-atmosphereinteraction and biodiversity loss (Boko, 2012). Human activities have inrecent years be recognized as a major force shaping the biosphere (Meyer and Turner II, 1994) .

Global demand for the product of land is likely to continue accelerating in the foreseeable future. The capacity of the land and of the environment more generally to sustain that demand will remain an issue of fundamental importance (Meyer and Turner II, 1994). It has become increasingly important as the nation plans to overcome the problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, loss of fish and wildlife habitat. Landuse data are needed in the analysis of environmental processes and problems that must be understood, if living conditions and standards are to be improved or maintained at current levels (Anderson, 1976).

The major factors that have resulted in loss of vegetation cover are increase in population, urban expansion and deforestation (Robson and Berkes, 2011; Carlson and Arthur, 2000). Also, for the survival of mankind, more vegetation areas have been converted to farmland (Aduah and Aabeyir, 2012), sites for established companies and expansion of settlements (Fabiyi, 2011). Thus, exposing these areas to air pollution which could have been resolved by the presence of vegetation. Landuse decision can exacerbatenatural hazards and soil erosion, alter the hydrological balance, pollute surface and ground water, destroy wildlife habitats, increase energy use and air pollution and diminish community character and quality of life.

In Benin Republic, the environmental dynamic is manifested by a reduction of forest areas and an uncontrolled extension of agricultural lands (Oloukoi, 2012). Prediction of future landuse/landcover image is the latest research which will be very much useful to the urban planning and natural resources management (Kumar *et al.*, 2015). In this context, it is much needed to estimate the landuse changes over the time and predict future scenario (Mishra et *al*., 2014). Thus, remote sensing based on Land Change Modeler method (LCM) using the trend of 2000 and 2013 is particulary suitable for this type of analysis. The objective of this study is to analyze the dynamism in the trend of landuse and landcover, evaluating the evolution of landuse and landcover and predicting its state at 2025 and 2050.

THE STUDY AREA

The study area is located in west northern part of republic of Benin (**Figure 1**). It lies between latitude 10°57'39" and 11°40'52" North and longitude 1°59'44" and 2°54'46" East . It is bordered in the south by Gogounou district, South-West by Kerou district, North-East by Burkina-Faso Republic and in the west by Karimama district. It covers about 4420 km².

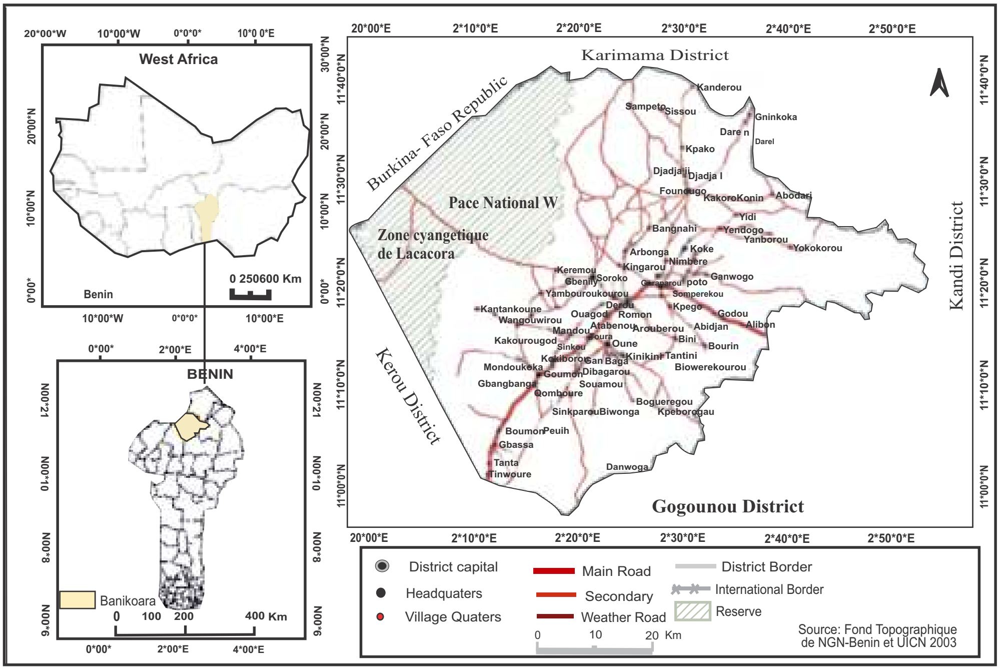


Figure 1: The Study Area

The study area is characterized by dynamic of landuse and landcover. It belongs to Sudanian climatic zone with the average rainfall between 850 and 1000 mm (ASCENA, 2011). The average temperature is about 27.7°C at Kandi, the only synoptic station near to the study area. The hot period of the year is between March and April with38.6°C daily (Toko, 2014). The lower temperatures are also recorded during the harmattan which is a dry cold air mass blowing north - south from December to February. The monthly average relative humidity is between 26 and 81 %.

The geology of the study area is characterized by sandstone, schist, jasper and quartzite. The soils are mainly ferruginous tropical. There are also feralitic and hydromorphic soils that support a vegetation cover typical of humid savannah conditions. The main cover types are natural vegetation which varies from pockets of natural forests to herbaceous savannah. It consists of bush savannah, tree savannah, a mixture of the two savannahs, as well as riparian or gallery forest along the rivers and the streams.

METHODOLOGY

The research focuses on the analysis of landuse and landcover change based on Remote Sensing. The summary of methodology is presented in **Figure 2.**

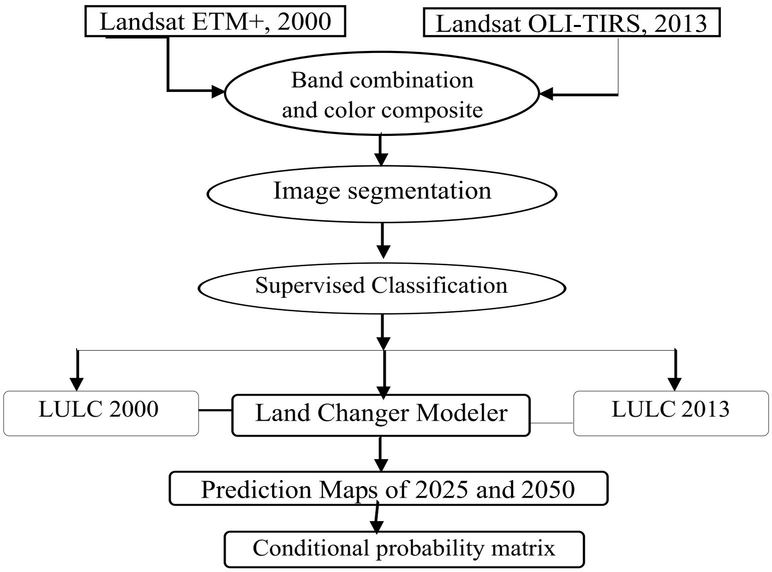


Figure 2: The Methodology flow chart

Landsat ETM+ and OLI-TIRS image with 30 m resolution is acquired freely from the United States Geological Survey (USGS) website. They are used to generate the landuse and landcover for 2000 and 2013 by supervised classification based on image segmentation using IDRISI Selva. The Image segmentation consists of gathering the spatial close pixel. The visual interpretation was done by means of the interpretation keys such as size, shape, texture, pattern, tone, color and association of the features. All of them were based on image segmentation to identify the landuse and Landcover elements (Chabi-Adimi, 2015). There are savannah, water, farm and fallow land, gallery forest, dense forest, light forest and woodland and built-up. The vegetation (gallery forest, dense forest, light forest and woodland) represents areas covered by trees of different species and sizes, shrubs and woody plants among others. Waterbody refers to ground surface water (mainly reservoir, rivers and streams). The maximum likelihood algorithm has been used for running classification.

The simulation of landuse and landcover for 2025 and 2050 by using 2000 and 2013 image classification, CA_MARKOV and LCM was done with IDRISI selva. In IDRISI (CA_MARKOV and LCM), the projections are also performed by creating a matrix to calculate the quantity of each landuse and landcover for a desired date. When the date being projected forward is a multiple of the calibration period, this transition probability matrix is calculated using a simple powering.

The Markov chain is stochastic events, where the current state of a variable or system is independent of all past states except the current state.

RESULTS AND DISCUSSION

Landuse and landcover dynamic between 2000 and 2013

The study area recorded a signicant change in landuse and landcover between 2000 and 2013, especially for farm and fallow land, savannah and light forest and woodland(**Figure 3** and **Figure 4**).

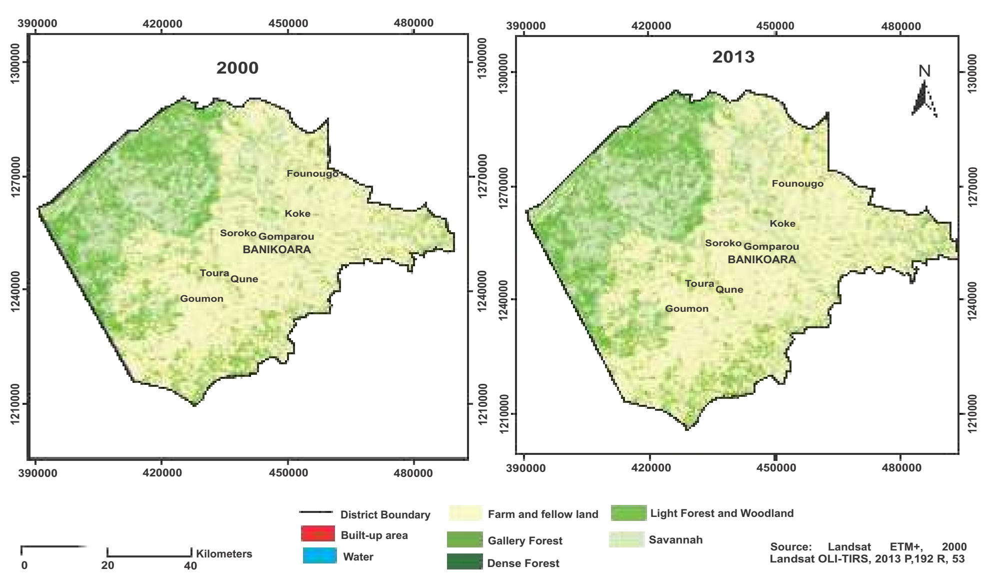


Figure 3: Landuse and Landcover maps for 2000 and 2013

Figure 4: Gains and Losses of landuse and landcover between 2000 and 2013

From **Figure 4**, it is clear that there are significant changes and transitions among various landuse/landcover classes during the period from 2000 and 2013. The main changes and transitions are basically among farm and fallow land, light forest and woodland and savannah. The farm and fallow land lost about 16,876 ha and gained 129,108 ha. At the same time, the savannah has lost 121,133 ha and gained 36,483ha, the Light Forest and woodland has lost 66,200 ha and gained 37,771 ha. Generally, the different types of vegetation have lost in profit of farm and fallow land.

Trend of landuse and landcoverat 2025 and 2050 horizon

Vis a vis the dynamics of landuse and landcover between 2000 and 2013, it is important to estimate the impact of the anthropogenic activity especially agriculture on the future environment. The environment and stimulation modeling base on Land Change modeler and Markov chain of IDRISI selva has been used to predict the landuse and landcover of 2025 and 2050. This prediction is based also on the probability of change matrix of 2013 to 2025 and 2013 to 2050 (**Table 1, Table 2**).

Table 1:Probability of change matrix between 2013 and 2025

LULC2025 / LULC 2013	Built-up	Light forest and woodland	Dense Forest	Gallery forest	Farm and fellow land	Water	Savannah
Built-up	0.2414	0.0000	0.0000	0.0000	0.7160	0.0020	bnjfyde6
Light forest and woodland	0.0007	0.4122	0.0018	0.0564	0.2754	0.0008	0.2526
Dense Forest	0.0006	0.3233	0.0042	0.3449	0.1588	0.0005	0.1676
Gallery forest	0.0005	0.1283	0.0289	0.5952	0.1400	0.0003	0.1069
Farm and fallow land	0.0066	0.0669	0.0003	.0019	0.8653	0.0009	0.0581
Water	0.0086	0.0611	0.0001	0.0074	0.0955	0.3858	0.4415
Savannah	.0075	0.1191	0.0001	0.0063	0.4452	0.0011	0.4208

Table 2: Probability of change matrix between 2013 and 2050 (Based on LULC of 2000 and 2013)

LULC2050 / LULC 2013	Built-up	Light forest and woodland	Dense Forest	Gallery forest	Farm and fellow land	Water	Savannah
Built-up	0.0202	0.0855	0.0004	0.0062	0.7917	0.0017	0.0943
Light forest and woodland	0.0062	0.1586	0.0023	0.0507	0.5934	0.0014	0.1874
Dense Forest	0.0049	0.1640	0.0069	0.1475	0.4937	0.0011	0.1819
Gallery forest	0.0041	0.1568	0.0109	0.2304	0.4316	0.0010	0.1654
Farm and fallow land	0.0079	0.1043	0.0007	0.0120	0.7624	0.0014	0.1113
Water	0.0087	0.1237	0.0008	0.0189	0.5257	0.0549	0.2674
Savannah	0.0078	0.1239	0.0009	0.0187	0.6801	0.0015	0.1670

The analysis of these two tables show that the tendency observed between 2000 and 2013 will continue. That is justified by the high probability for all types of vegetation to become farm and fallow land. On the basis of probability of change of different classes, the landuse and landcover maps of 2025 and 2050 were predicted as shown in **Figure 5**.

The analysis of figure 5 confirms the tendency showed by probability of change matrix. It showed the decrease of vegetation between 2013 and 2025, 2025 and 2050 in profit especially of farm and fallow land. In general, the trend between 2000 and 2050 (**Figure 6**).

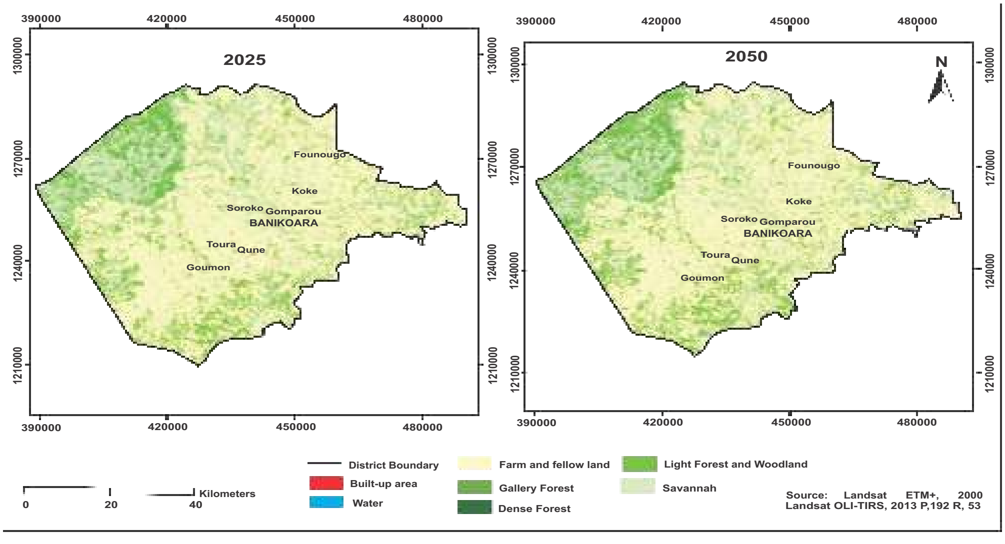
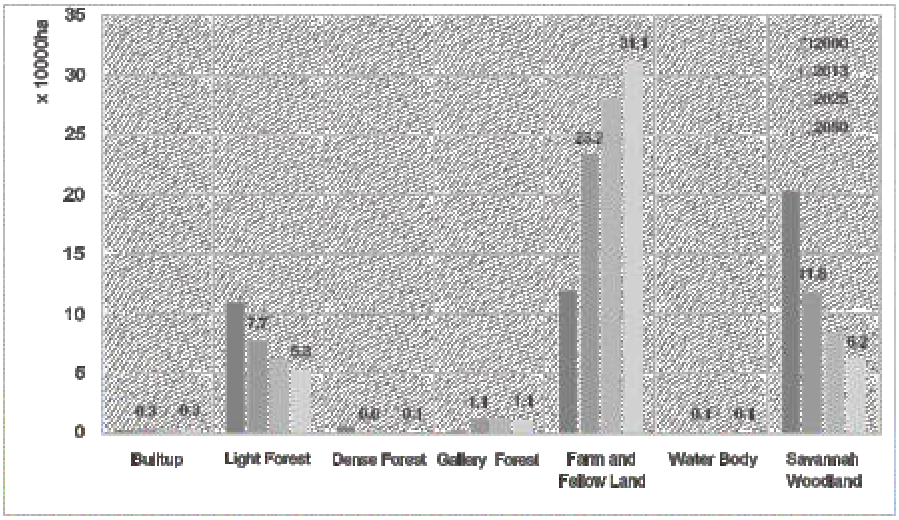


Figure 5: Landuse and landcover maps for 2025 and 2050



6: Statistics of landuse and landcover 2000, 2013, 2025 and 2050

The analysis of figure 6 shows that between 2000 and 2013, the savannah and light forest had considerably decreased in profit of Farm and fallow land and this tendency will continue to 2050.The dense and gallery forest decreased also between 2000 and 2013 but it will increase between 2013 and 2050. That is justified by the presence of protected area in the study area.

DISCUSSION

Remote Sensing and the Land Change Modeler used for this paper allow to determine the landuse and landcover change tendency in Banikoara District. The result obtained dependson the data used for the study. If the satellite Image used for this study is recent, it is important to notify that the supervised classification, based on image segmentation used for extraction of landuse and landcover cannot give total precision. The global precision of this classification is 95 %. The Land Change Modeler is also based on probability of change. Thus, the probability of change of these different classes cannot also give 100 % precision of change.

In spite of these limitations, this paper shows the ability of Remote Sensing to analyze the dynamics of landuse and landcover change at Banikoara district. The result obtained is similar to the results of Mishra et *al*. (2014) at Muzaffarpur (Bihar), India. Like these authors, Nauss and Bendix (2012) analyse the tendency of landuse and landcover change between 1987 and 2001 using medium remote sensing image in tropical mountain forest of southern Ecuador. They also predict the future scenario for landuse and landcover based on Markov Chain analysis. Kumar et *al*. (2015) analyze the dynamic of landuse and Landcover in Vijayawada City. They predict the state of landuse and landcover in horizon 2040.

Oloukoi (2013) show also the importance of Remote Sensing in landuse and landcover change and for prediction using SpaCelle cellular automata. Like a Land Change Modeler integrated in IDRISI, based on Markov change analysis use for his paper, SpaCelle is based on probability of change of landuse and landcover units. It allows the author to predict the landscape units in the central region of Benin Republic.

CONCLUSION

Banikoara District like most of Benin Districts registered a high dynamism in landuse and landcover change. Between 2000 and 2013, the district lost important part of his vegetation in profit of farm and fallow land. However, the presence of reserve shows that the rate of loss will reduce in the future. This research has shown the low level of urbanization of the district. Even if the built-up area increases, the rate of increase is very low when compared to the increase rate of farm and fallow land.

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