Journal of Sustainable Development in Africa (Volume 17, No.7, 2015)
ISSN: 1520-5509
Clarion University of Pennsylvania, Clarion, Pennsylvania

MODELLING OF LAND USE AND LAND COVER CHANGE IN IBADAN NORTH-WEST LOCAL GOVERNMENT AREA (LGA), NIGERIA USING SATELLITE IMAGERIES AND GIS TECHNIQUES

Abiodun Olufemi Adebola[1], Suleiman Abdul-azeez Adegboyega.[1], Ayo Emmanuel Olajuyigbe[2], & Sunday Olu Oladejo[1]

[1]Department of Remote Sensing & GIS, Federal University of Technology, Akure.
[2]Department of Urban & Regional Planning, Federal University of Technology, Akure.

ABSTRACT

This study examines urban spatial change in land use and land cover of Ibadan Northwest Local Government Area (LGA) in Oyo State. The general patterns of land use/cover as they were recorded in remotely sensed data were analysed. Multi-date satellite imageries (Landsat ETM+ 2000, Landsat ETM+ 2014 of 30m spatial resolution respectively were obtained and used for the study. These images were enhanced, geo-referenced and classified using IDRISI software. The result of ground truthing was combined with visual image interpretation as training sites for supervised classification. To predict land use land cover change of the area in the next 7 years, CA-Markov chain analysis, a land cover prediction procedure was introduced. The results showed that the natural environments (vegetation, wetland, water bodies, forest, grassland and built-up) were being threatened, as they reduced continually in the area extent over time and space while the social environment (built up area) expanded and this may likely be the trend between 2000 and 2021 as projected. The study discovered that urbanization processes is majorly responsible for land-use/land-cover change in Ibadan North-west. In conclusion, the study advanced our frontier of knowledge on land use/cover study by providing information on the status of natural and social environment in Ibadan North-west, between 2000 and 2021 using remotely sensed images and Geographic Information Systems (GIS) technology.

Keywords: Urban, Land-Use, Land-Cover, Predictive Modeling, CA Markov Chain Analysis, Satellite Imageries

INTRODUCTION

In recent times, the dynamics of Land use Land cover and particularly settlement expansion in the area requires a more powerful and sophisticated system such as remote sensing and geographic information system (GIS), which provides a general coverage of large areas than the method employed in the past. In the past two centuries the impact of human activities on the land has grown enormously, altering entire landscapes, and ultimately impacting the earth's nutrient and hydrological cycles as well as climate (De Sherbin, 2002). Significant population increase, migration, accelerated socio-economic activities, increased demands on the landscapes for food and shelter and an increased number of products of man’s living environment have led to un-parallel changes in land use and modification of rural and urban environment, these changes have made sustainability of the environment difficult. Information about the earth and our environment can be extracted from imagery obtained by various sensors carried in aircraft and satellites (Paul and Charles, 2002). The advent of geographic information system (GIS) has made it possible to integrate multisource andmulti-date data for the generation of landuse and landcover changes involving suchinformation as the trend, rate, nature, location and magnitude of the changes Adeniyi et al (1999). This has been very useful to various relevant authorities in ensuring sustainable development. Remotely sensed data have been applied in many fields like forestry, geology, agriculture, conservation and planning etc. (Paul et al, 2002).The role of planning agencies, for example, is becoming increasingly more complex and is extending to a wider range of activities. Consequently, there is an increased need for these agencies to have timely, accurate and cost-effective sources of data of various forms. Several of these data are well served by visual and digital image interpretation. A key example is land use land cover mapping (Lillesand, Kiefer and Chipman, 2008). Major consequences of the globally recognized rapid land use and land cover changes are; land degradation, loss of biodiversity, agricultural yield depletion and ecosystem functioning. Due to poorly planned human interference, many African countries have experience untold environmental degradation and ecological deterioration in the past century, with little or no real solution to alleviate many of these concerns. Adequate information and appropriate technology are limited factors for effective environmental management.

In situations of rapid and often unrecorded land use change, viewing the earth from space provides objective information of human utilization of the earth. Remote Sensing and Geographic Information System (GIS) are now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the analyses of Earth - system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity (Wilkie and Finn, 1996). Therefore, an attempt was made in this study to map out the status of land use land cover of Ibadan Northwest between 2000 - 2014 with a view to detecting the land consumption rate and the changes that have taken place particularly in the built-up and vegetated areas so as to predict possible changes that might take place in the next 20 years using both Geographic Information System and Remote Sensing tools.

Urbanization in Nigeria is not a recent phenomenon, thus the growth and development of cities in Nigeria is very similar to the urbanization process in other African countries. The south western part of Nigeria has the highest urbanization level (Aloba, 2004). It is generally believed that urbanization has both direct and indirect impacts on land use transformation. Abubakar, *et al.* (2000) in their study on assessment of environmental degradation using satellite remote sensing technologies, they examine landuse/landcover changes in TalataMafara area of Zamfara state, Nigeria. Their results showed that changes among six land use / land cover classes between 1986 and 1995, Agricultural land increased from

117.00 km^2 to 158.50 km^2, while grass, shrub and thicket Land cover decreased from 20.13km^2 to 12.50 km^2. There was a drastic increase in bare surfaces from 5.38 km^2 to 27.13 km^2. Settlement showed a slight decrease from 1.25 km^2 to 1.13 km^2 rather than the expected growth. Uncultivated vegetated wetland also showed a decrease from 14.63 to 8.25 km^2 and Water bodies increased from 3.88 km^2 to 5.00 km^2.

Bhaduri, *et al*. (2000) used L-THIA to assess long-term hydrologic impacts of land use change with special attention given to small and low-frequency storms in the Little Eagle Creek in Indianapolis, Indiana (70.5 km^2). Daily precipitation from 1966 to 1995, with 1973, 1984, and 1991 land use data were used for the simulations. The study determined that an 18% increase in urban and impervious areas resulted in approximately 80% increase in annual average runoff volume, more than 50% increase in heavy metal loads (lead, copper, and zinc), and 15% increase in nutrient loads (phosphorus and nitrogen. Adetunji and Adegboyega (2011) examined the spatio-temporal pattern of city development and travel characteristics of urban resident of Ilesa. Satellite imagery of ilesa taken in 1986, 1998, 2002, and 2008 were used as source of primary data to compliment the administrative map of 1948, 1965, nd1977. The study reveals that the expansion ofIlesa was alarming between 1948 and 2008 at 57.4%, when the built-up area of Ilesa attained a net increase of 52km^2 to reach 62.7km^2 in 2008.The Earth Summit, United Nations Conference on Environment and Development (UNCED), which took place in Rio-De-Janeiro in 1992, recognized the pressing environment and development problems of the world and through the adoption of Agenda 21, produced a global programme of action for sustainable development in the 21st century. Agenda 21 stresses the importance of partnership in improving social, economic and environmental quality in urban areas. It suggests renewed focus on effective land use planning to include adequate environmental infrastructure, water, sanitation, drainage, transportation, and solid waste in addition to a sound social infrastructure capable of alleviating hunger. However, the urban expansion in Ibadan mostly occur in an unguided, unplanned, uncoordinated and unsystematic manner thereby paving way for sprawling development due to unprecedented urban pressures. Therefore, modeling the land use in the study area will go a long way to predict future development and assist to check urban development to appropriate area thereby ensuring a sustained urban growth.

MATERIALS AND METHODS

Research locale

Ibadan Northwest is located within longitude 3.8^{0}E and3.9^{0}E, latitude 7.3^{0}N and 7.4^0.N. The study area has an aerial extent of about 26km^2**.** It's headquarter is at Dugbe/Onireke and it has a population of 152,834 at the 2006 census. Population increase is about +3.46% per year (2006- 2011). Estimated population as at 2010 is 173,359. The climate of the region is tropically wet and dry with a lengthy wet season and relatively constant temperature throughout the course of the year. The wet season runs from march through October, also there are two peaks for rainfall, which are; June and September. The mean temperature is 26.46^{o}c, and minimum is 21.42^{o}c, while the relative humidity is about 74.55mmHg.

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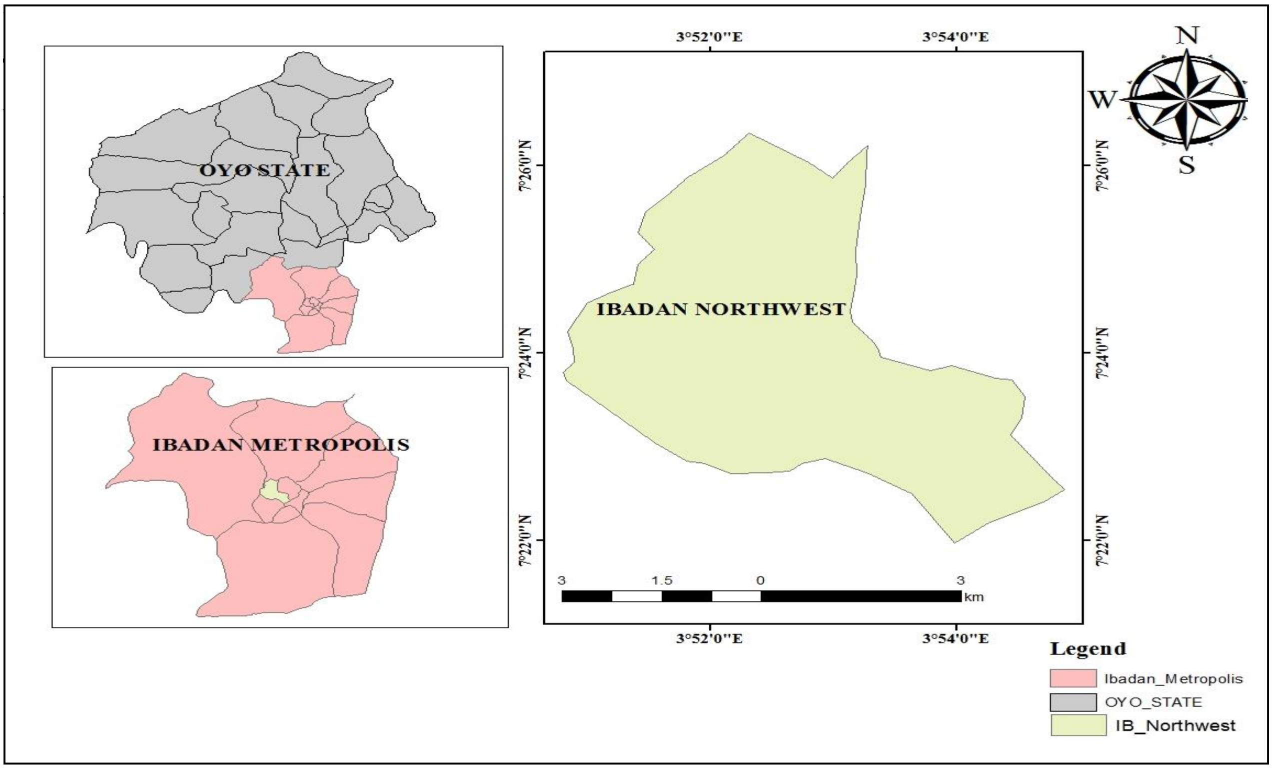

Fig 1: Map of Study Area

Nature of Data

Satellite Image

Two Landsat ETM+ images were used, taking into consideration data quality and availability. These were year 2000 and 2014 respectively with path and row 191, 55 of the Landsat Enhanced Thematic Mapper (ETM+). The images were downloaded from the internet. The local government boundary map and Administrative map of Nigeria was the source from which the study area shape file was clipped out, this was done using ArcGIS. The images had different resolutions with the 2000 image with a resolution of 28.5m and the 2014 image with a resolution of 30m.

Table 1. Characteristics of Landsat TM and ETM+

S/NO	Satellite type	Resolution	Path/row	Spectral band	Source	Year
1	LANDSAT TM	28.5m	191/55	7BANDS	GLCF	2000
2	LANDSAT ETM+	30m	191/55	7BANDS	GLCF	2014

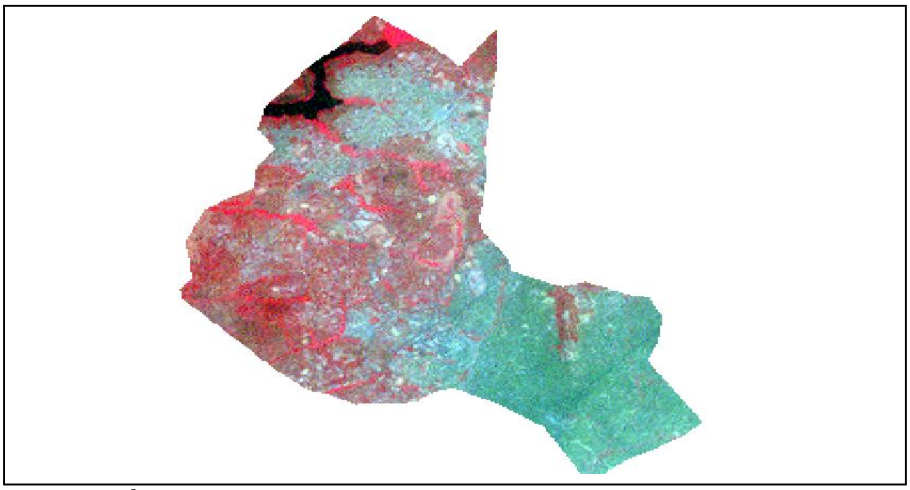

FIG 2: Band 432 composite in 2000.

FIG 3: Band 432 composite in 2014.

Development of a Classification Scheme

Multi-date satellite imageries (Landsat ETM+ 2000, Landsat ETM+ 2014 of 30m spatial resolution respectively) were obtained and used for the study. The images were obtained in the same season. All the images were enhanced, geo-referenced and classified for the assessment of spatio-temporal pattern of land use/cover change in the study area. The band combination used for this study is 4, 3 and 2 (RGB) and band 5, 4, 3(RGB). In this study, the satellite images were classified using supervised classification method. The combine process of visual image interpretation of tones/colours, patterns, shape, size, and texture of the imageries and digital image processing were used to identify homogeneous groups of pixels, which represent various land use classes of interest. To validate the tonal values recorded on the satellite images with the features obtained on the ground and also to know what type of land use/cover was actually present,Quickbird map of the study area was printed and was used as guide to locate and identify features both on ground and on the image data. The geographical locations of the identified features on the ground were clearly defined. These were used as training samples for supervised classification of the remotely sensed images. Based on this, a classification scheme was developed for the study area.

Table 2: Land Use Land Cover Classification Scheme

Code	Land-use/Land cover categories
1	Built-up Land
2	Derived savanna/Farmland
3	Water Body
4	Bare Land
5	Wet Land
6	Thick vegetation
7	Light vegetation

Change Detection and Prediction

Percentage change to determine the trend of change can be calculated by dividing observed change by sum ofchanges multiplied by 100

$$\text{(Trend)percentage change} = \frac{\text{observed change}}{\text{sum of changes}} x\ 100 \qquad (1)$$

Change detection involves the prediction of landuselandcover changes to a later period by estimating the percentage change of the area over a period of time. The algorithms in predicting change is; Stochiastic, and Cellular Automata (CA) _Markov. Markov chain is a convenient tool for modelling landuselandcover change when changes and the process of change are difficult to explain. It is achieved by developing a transition probability matrix of landuselandcover change from time to time, which shows the nature of change while at same time serving as the basis for projecting to a later period. CA_Markov uses the output from the Markov chain analysis to grow out landuse from time to time.

Predictive Modelling for Future Land use and Land cover Changes in Ibadan North-West

For this study two different techniques are used in the predictive modeling of the landuse/landcover change, they include the Markov Chain Analysis and the Cellular Automa (CA) Markov.

Markov Chain Analysis for Future Land Cover Change Prediction

Markovian model was used to create such a transition probability matrix.Conditional probability maps for each of the land cover type is shown below:

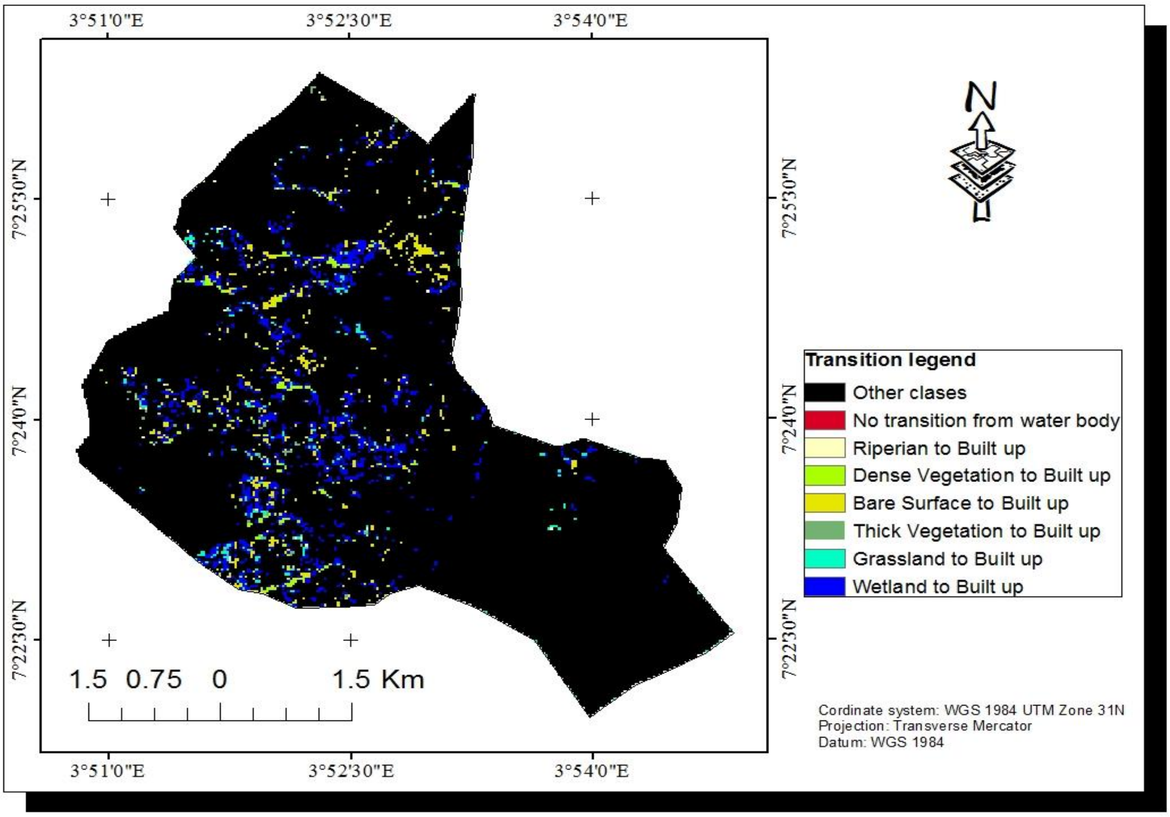

Figure 4 : Transition map from all other landcover classes to built-up landuse class

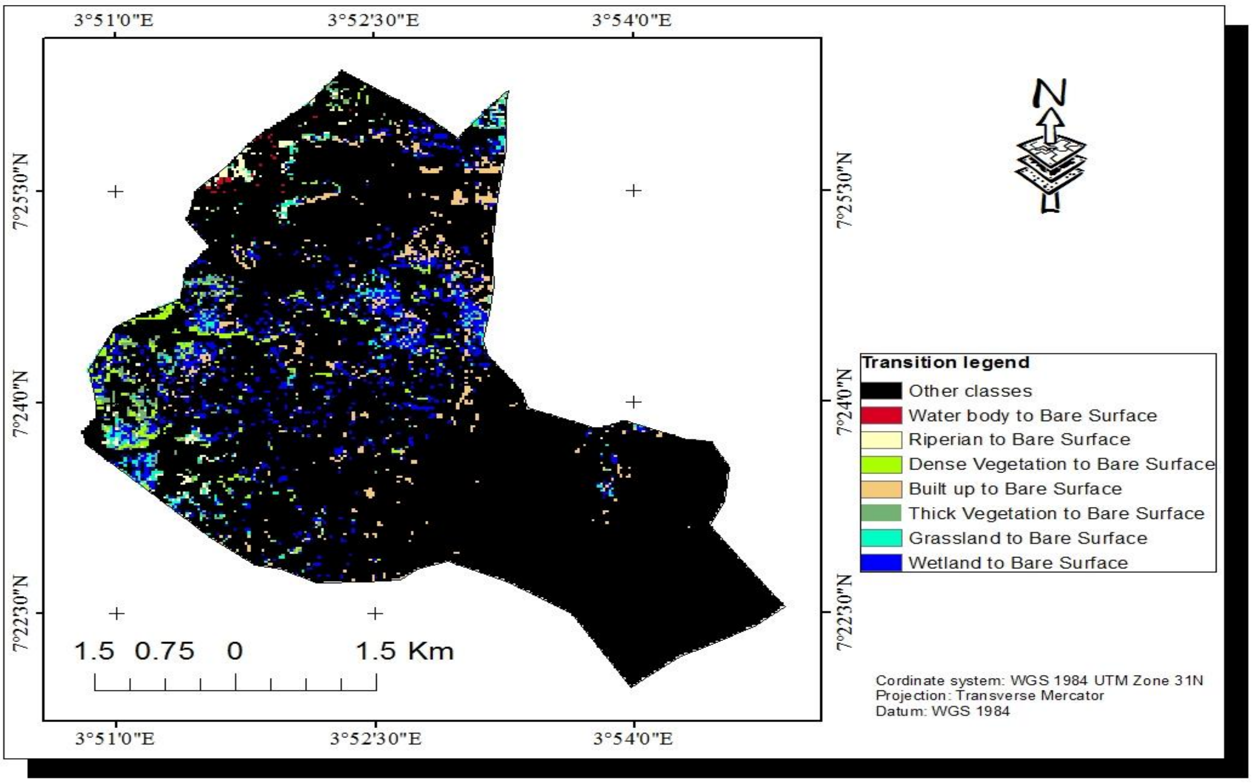

Figure 5: Transition map from all other landcover classes to bare surface landcover

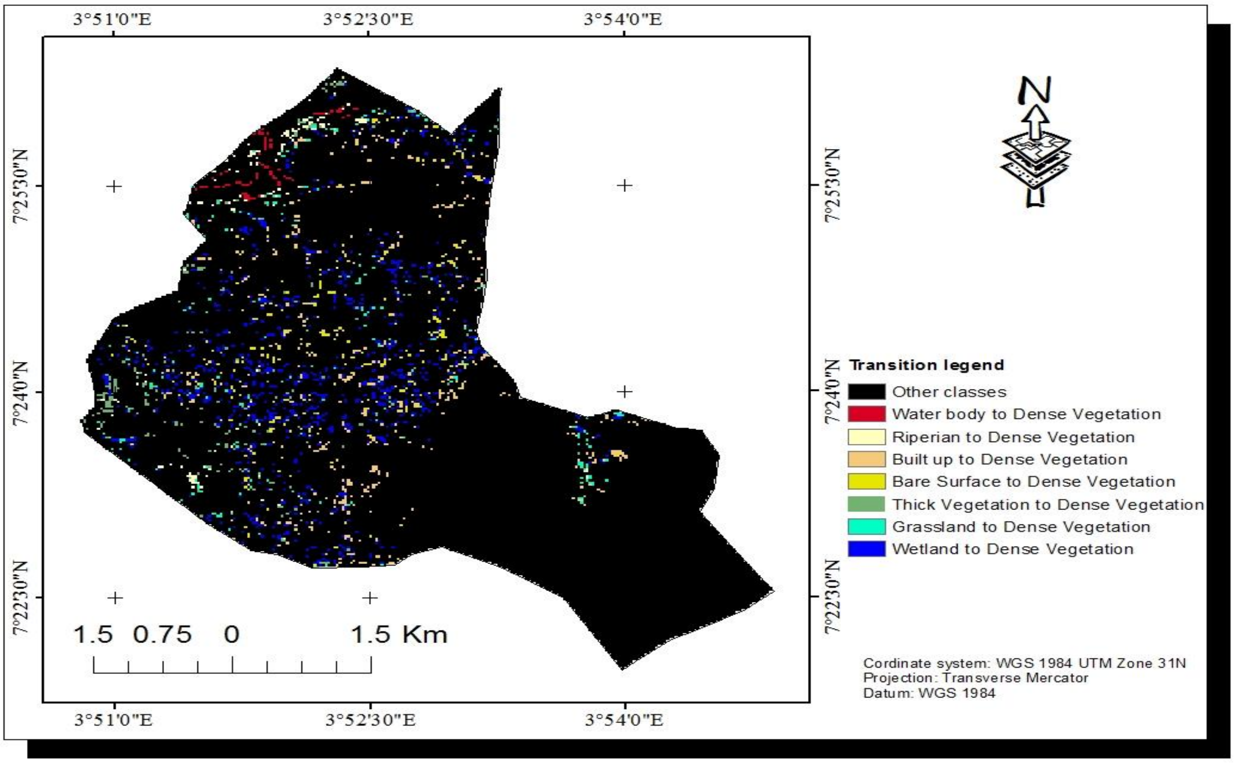

Figure 6: Transition map from all other landcover classes to dense vegetation

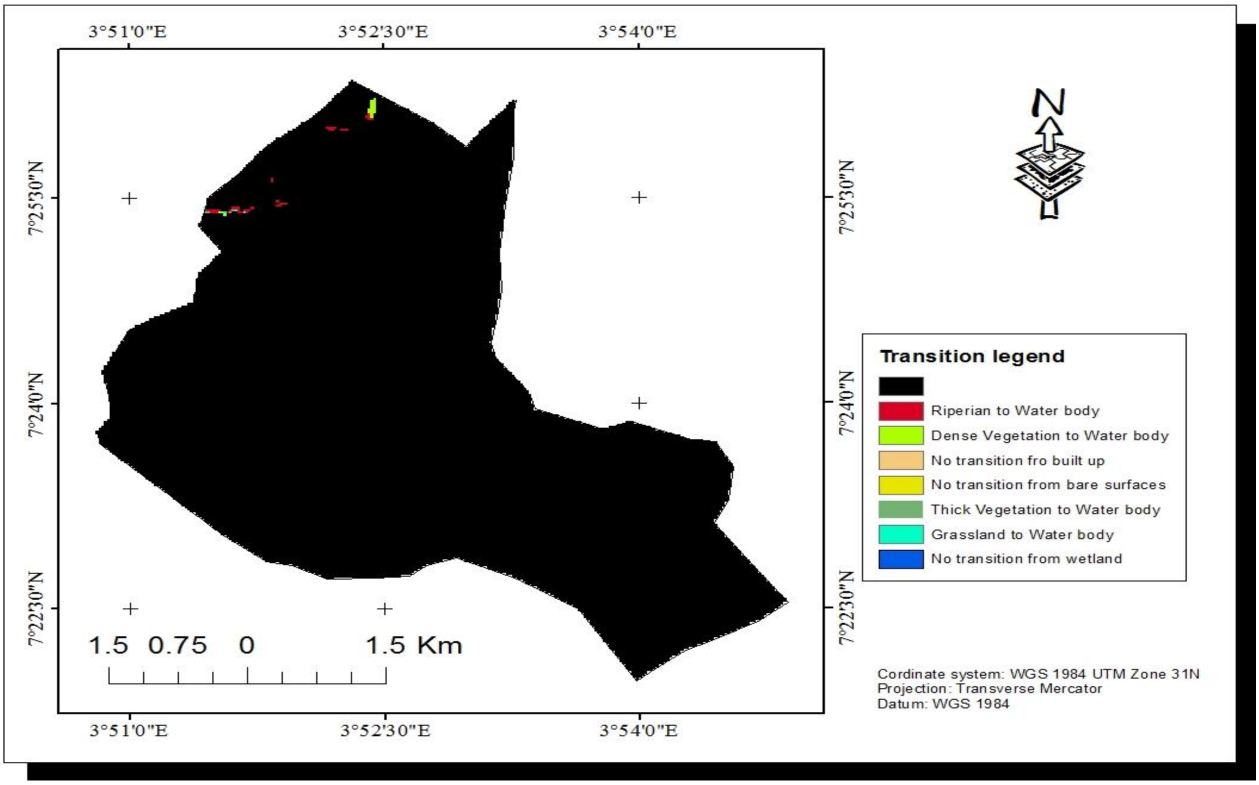

Figure 7: Transition map from all other landcover classes to water body

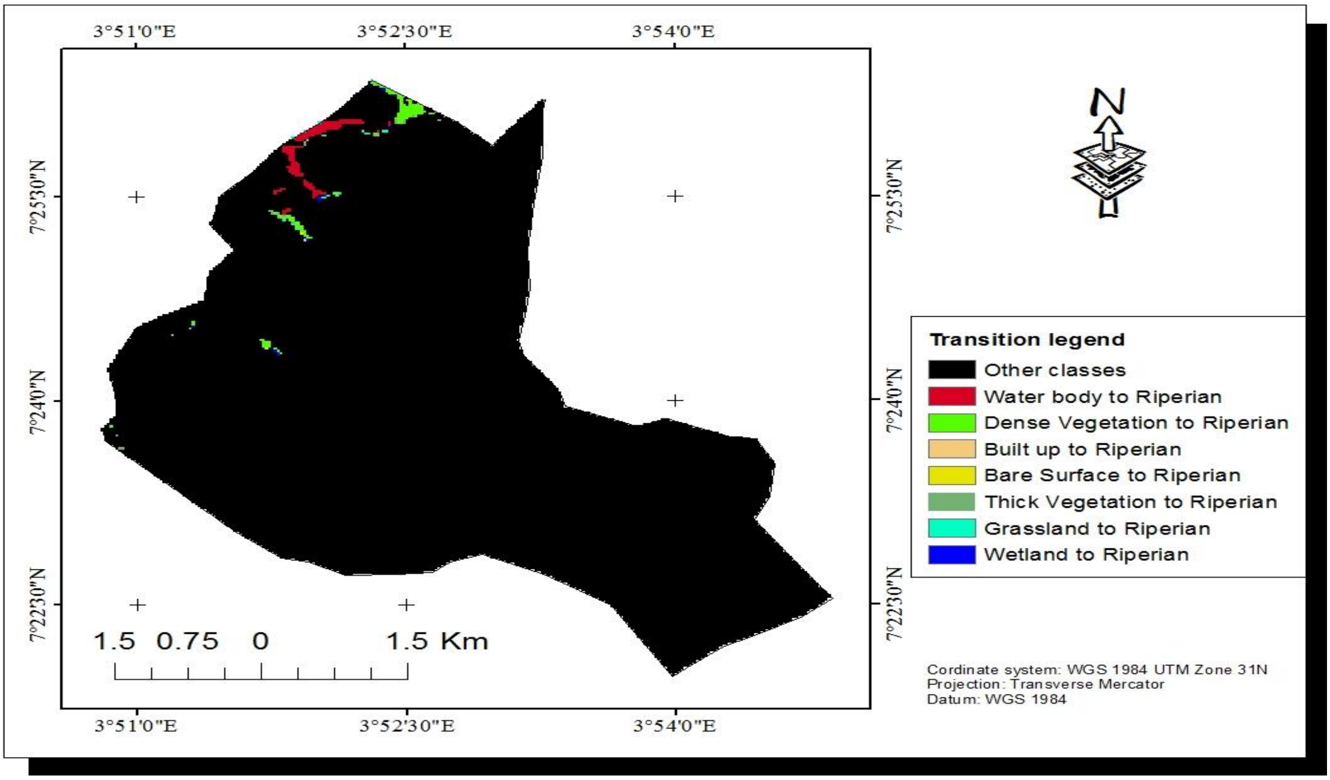

Figure 8: Transition map from all other landcover classes to riparian

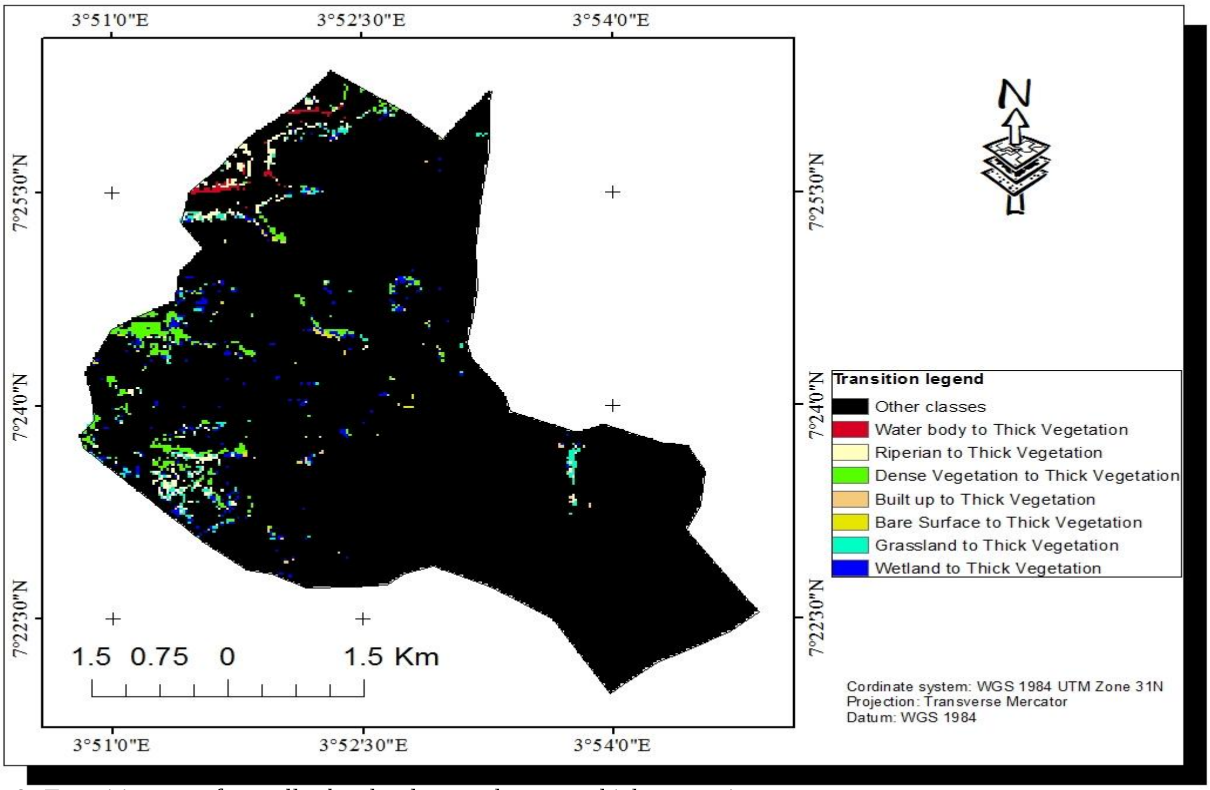

Figure 9: Transition map from all other landcover classes to thick vegetation

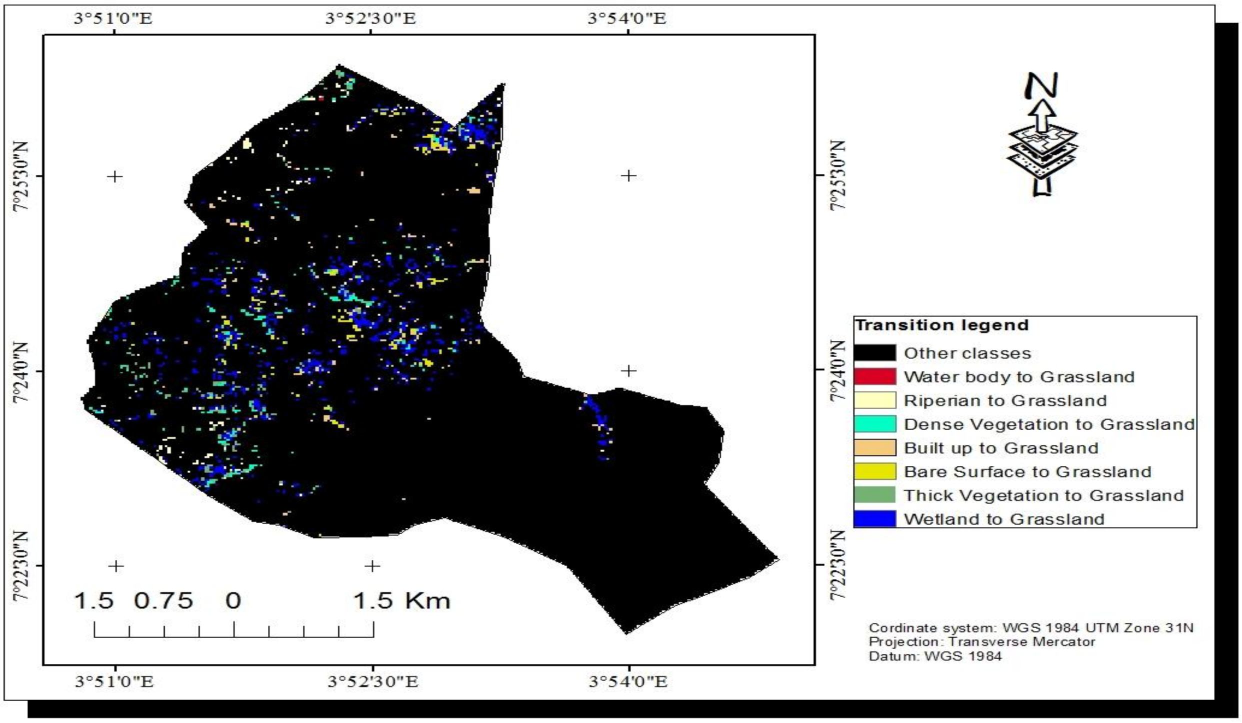

Figure 10: Transition map from all other landcover classes to grassland

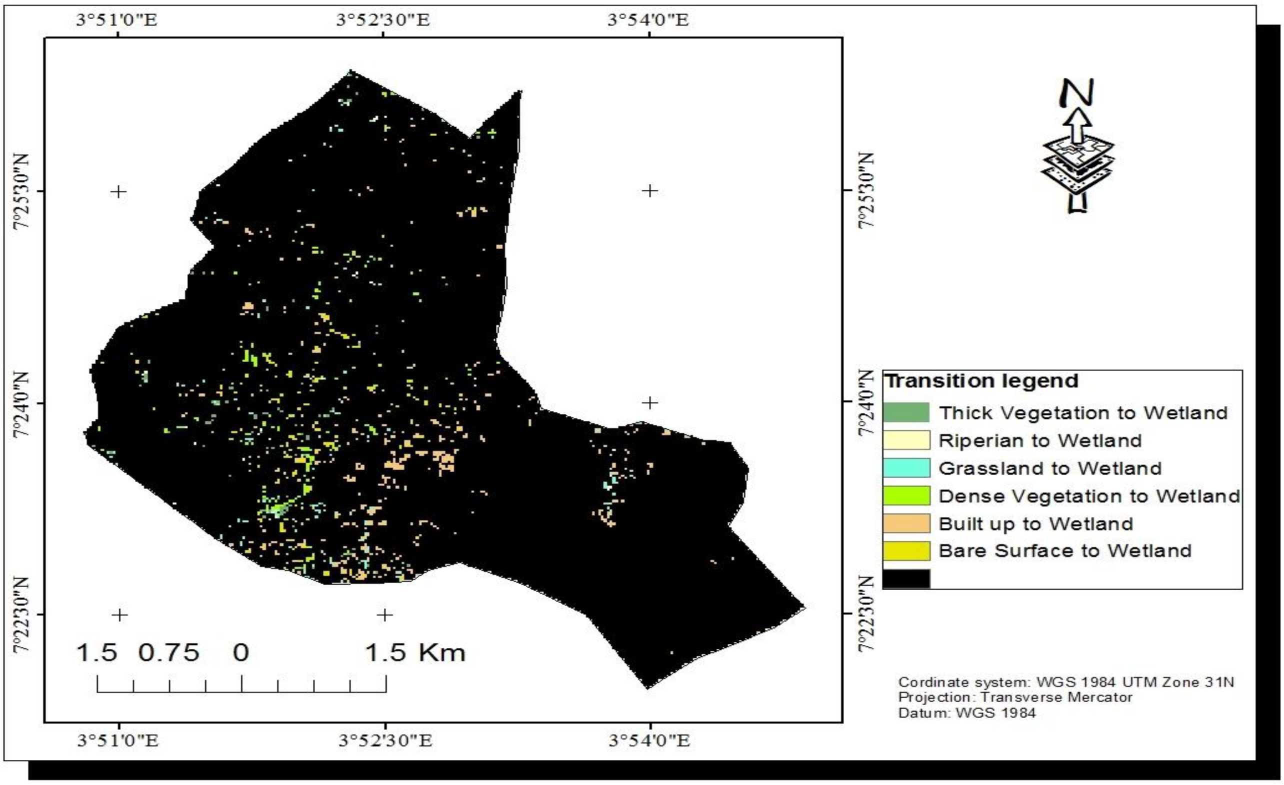

Figure 11: Transition map from all other landcover classes to wetland

Table 3: Landuse/landcover transition probability matrix

Year	2014								
2000	Classes	Water body	Riparian	Dense vegetation	Built up	Bare surfaces	Thick Vegetation	Grassland	Wetland
	Water body	0.5529	0.3180	0.0971	0.0000	0.0000	0.0313	0.0000	0.0000
	Riparian	0.0544	0.0746	0.1064	0.0000	0.2142	0.4364	0.1139	0.0000
	Dense vegetation	0.0094	0.0944	0.1744	0.0234	0.1821	0.3047	0.1065	0.1051
	Built up	0.0000	0.0000	0.0187	0.9259	0.0274	0.0000	0.0022	0.0258
	Bare surfaces	0.0000	0.0000	0.1385	0.1640	0.5026	0.0000	0.1026	0.0924
	Thick vegetation	0.0000	0.0131	0.1758	0.0000	0.2319	0.3779	0.1554	0.0458
	Grassland	0.0021	0.00087	0.1339	0.0735	0.2853	0.1912	0.2183	0.0870
	Wetland	0.0000	0.0000	0.1777	0.1624	0.2995	0.0187	0.1771	0.1644

Table 4: Transition Area Matrix

Year	2014									
2000	Classes	Water body	Riparian	Dense vegetation	Built up	Bare surfaces	Thick Vegetation	Grassland	Wetland	Total
	Water body	18.81	14.85	6.93	0	3.06	7.20	0.27	0	51.12
	Riparian	3.96	5.31	13.05	3.33	25.47	32.13	12.33	3.15	98.73
	Dense vegetation	1.80	11.43	31.05	19.89	45.09	46.26	22.68	17.91	196.11
	Built up	0	0.09	44.73	1218.15	78.84	4.68	18.90	49.32	1414.71
	Bare surfaces	0	0.18	27.90	56.88	82.17	4.77	21.78	18.99	212.67
	Thick vegetation	0.27	2.34	23.67	9.00	38.34	38.97	20.97	9.27	142.83
	Grassland	0.45	1.89	21.33	25.74	45.09	25.38	26.91	13.41	160.20
	Wetland	0	1.17	86.85	144.09	162.81	31.68	82.17	71.19	579.96
	Total	25.29	37.26	255.21	1477.08	480.89	191.07	206.01	183.24	2874.33

The above land cover transition probability matrix explains the probability of a land cover class changing to another land cover class within the period of 14 years. It shows maximum transition probability from riparian to thick vegetation and the lowest transition is seen to occur from grassland to water body, while no change is seen to be occurring from water body to built-up and wetland, within the period of 14 years from 2000 to 2014.It is also observed that built up area is the most consistent land cover type because it has the highest probability value of 0.93.

The landuse/landcover area (change) matrix shown in the table above explains the total area of land transferred from one class to another within the period of 14 years. The matrix shows that maximum change occurred from wetland to bare surfaces and minimum change from thick vegetation to water body.

Cellular Automata (CA) Markov Future Land-cover Change Prediction

A cellular automaton is an agent or object that has the ability to change its state based upon the application of a rule that relates the new state to its previous state and those of its neighbor. One of the basic spatial elements that under lies the dynamics of many change events is proximity, areas will have a higher tendency to change to a land cover class when they are near existing area of the same class. This is similar to that of the Markovian chain process with the only difference been the application of a transition rule that depends not only upon the previous state but also upon the state of local neighborhood. The predicted landuse/landcover map for this study was done for year 2020.

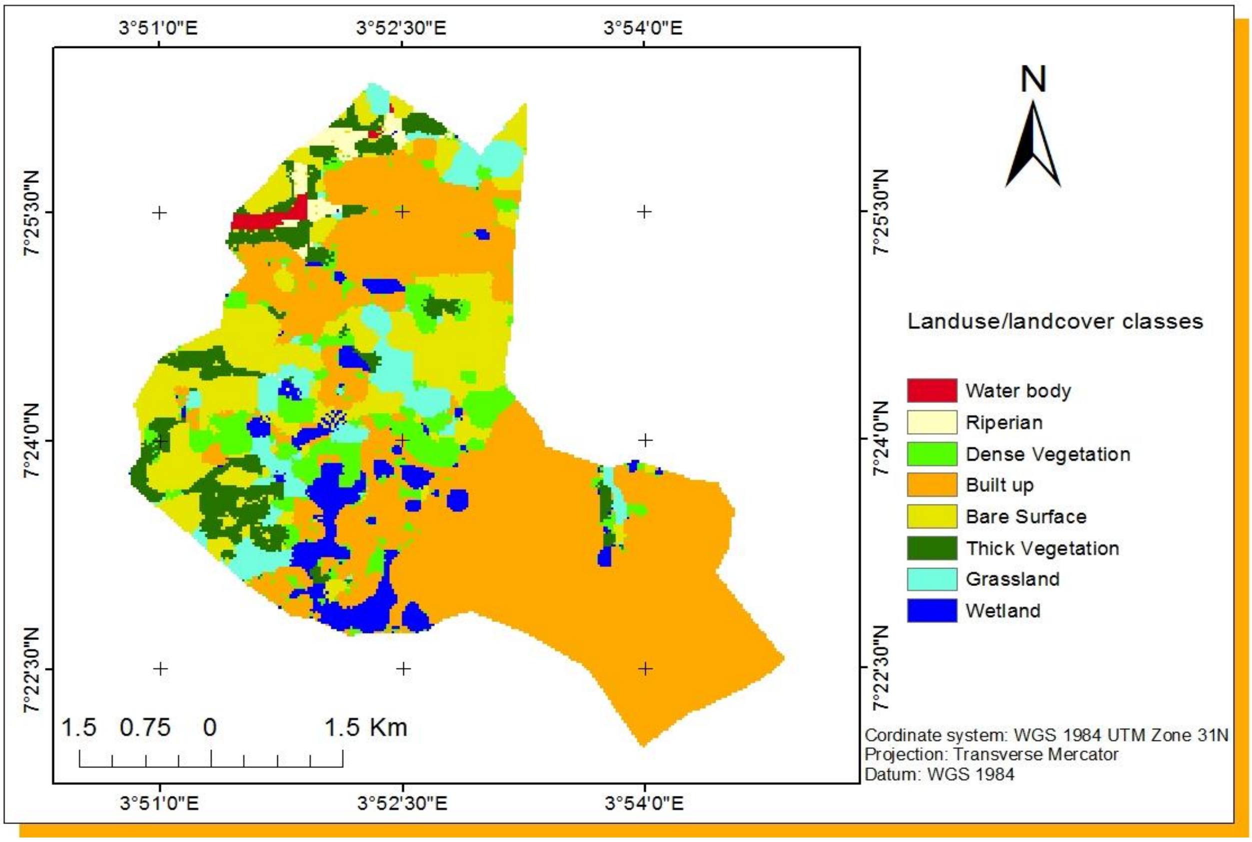

Figure 12: Predicted map for year 2020

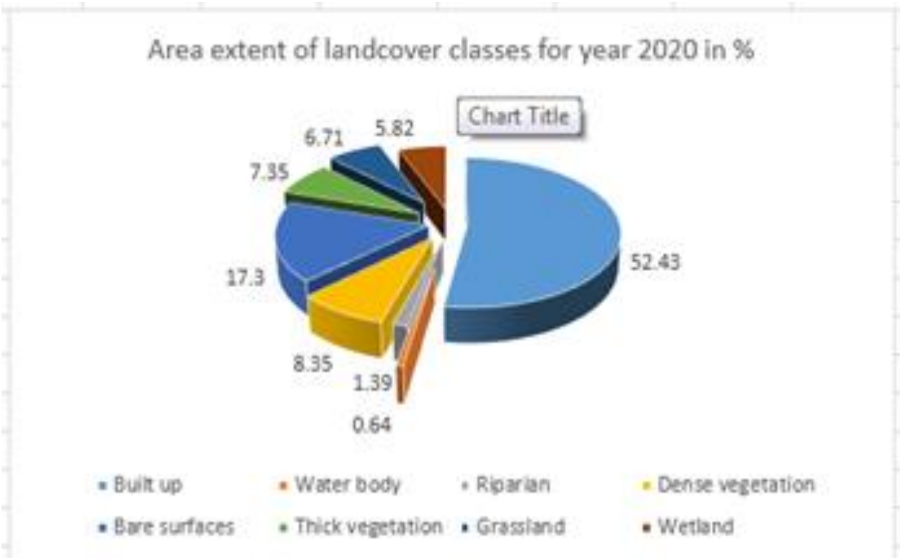

Figure 13: Area distribution of each of the landcover classes for year 2020

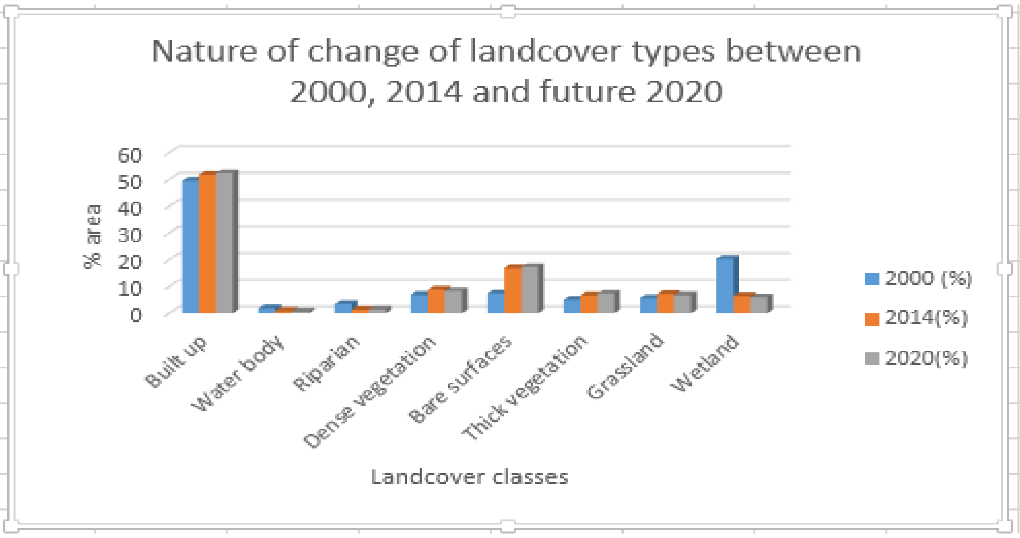

Figure 14: Nature of change to be expected in the year 2020.

From the figure above, it can be predicted that come year 2020, built up area, bare surfaces, thick vegetation and riparian will experience an increase in area of 0.72%, 0.46%, 0.66% and 0.09% respectively; while water body, dense vegetation, grassland and wetland would experience reduction in their covered area extent by 0.25%, 0.66%, 0.5% and 0.6% respectively.

Results and Discussion

Land Use Land Cover Distribution

Table 5: Categorised Land use and Land Cover Statistics for Ibadan North West LGA. (2000)

Land Use/cover Categories	2000	
	AREA (Ha)	AREA (%)
Bare Surface	205.47	7.2
Thick Forest	58.77	2.0
Light Forest	87.93	3.0
Derived Savanna/Farm land	161.91	7.6
Built-up	1197.99	40.1
Water body	46.89	1.7
Wet land	1086.21	38.2
TOTAL	2845.17	100

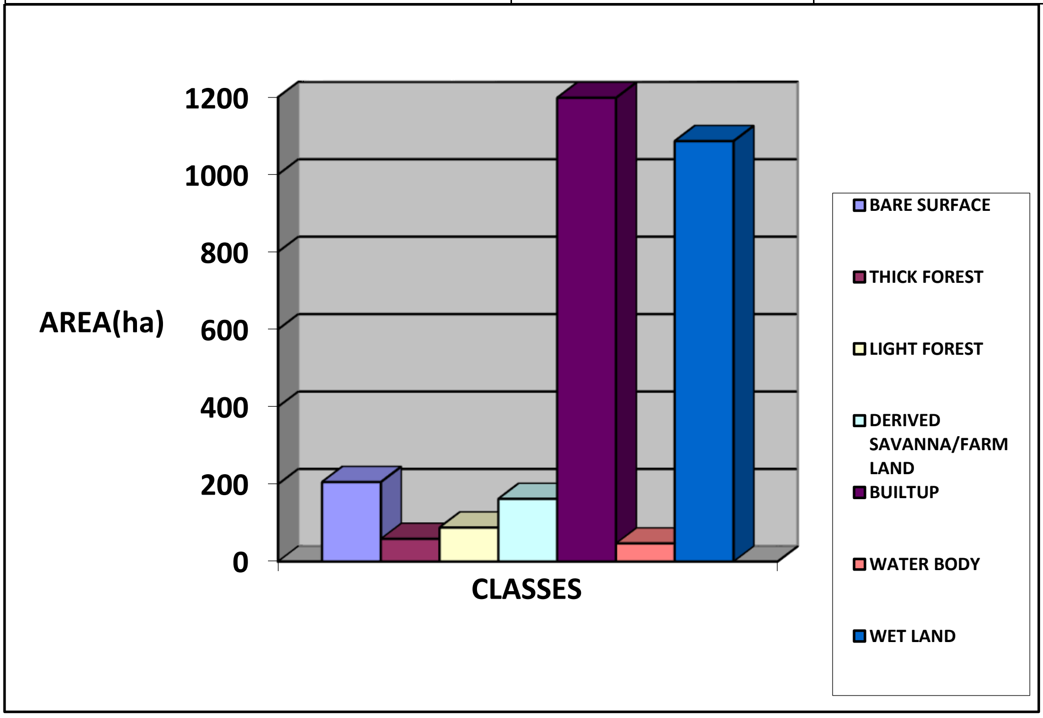

FIG 15: Histogram of 2000.

Table 6: Categorised Land use/ and Land Cover Statistics for Ibadan North West LGA. (2014)

Land Use/cover Categories	2014 AREA (HA)	AREA (%)
Bare Surface	341.91	11.90
Thick Forest	91.80	3.20
Light forest	55.26	1.90
Derived savanna/farmland	280.53	9.80
Built up area	1211.22	42.40
Water body	21.33	0.75
Wet land	854.19	29.90
TOTAL	2856.24	100

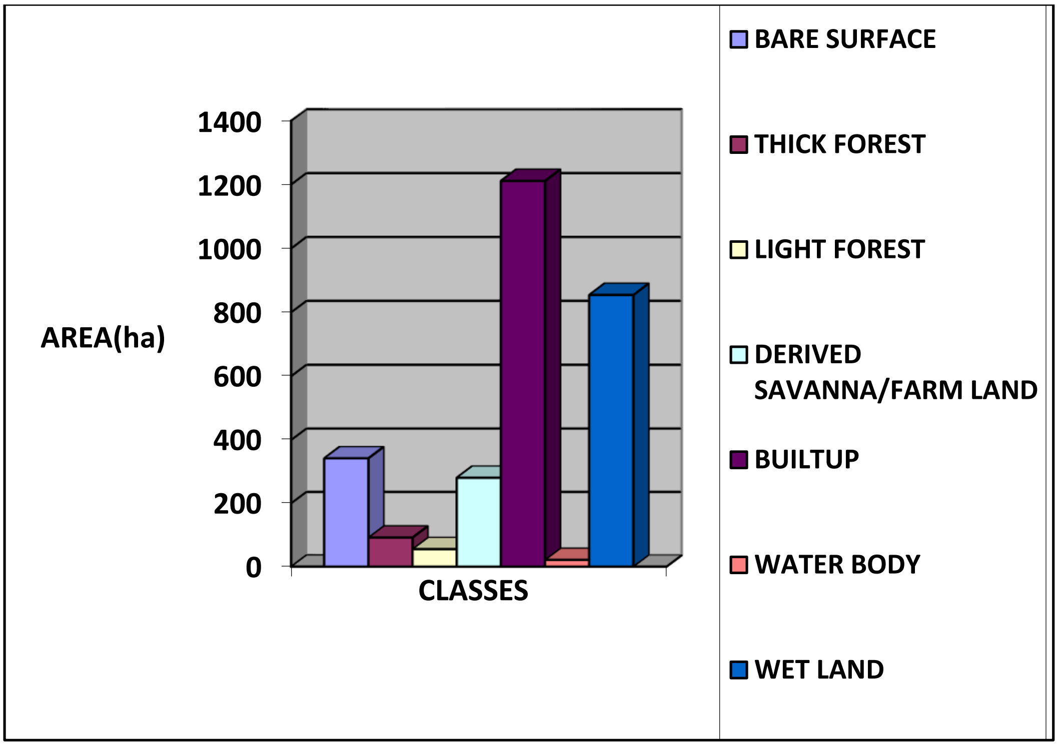

FIG 16: Histogram of 2014.

Table 7: Land use and Land Cover Statistics for Ibadan North West LGA. (2021)

Land Use/cover Categories	2021 AREA (HA)	AREA (%)
Bare surface	361.26	12.70
Thick forest	46.62	1.64
Light forest	89.50	3.15
Derived savanna/farmland	289.08	10.16
Built up	1213.29	42.64
Water body	15.30	0.54
Wet land	830.16	29.18
TOTAL	2845.17	100

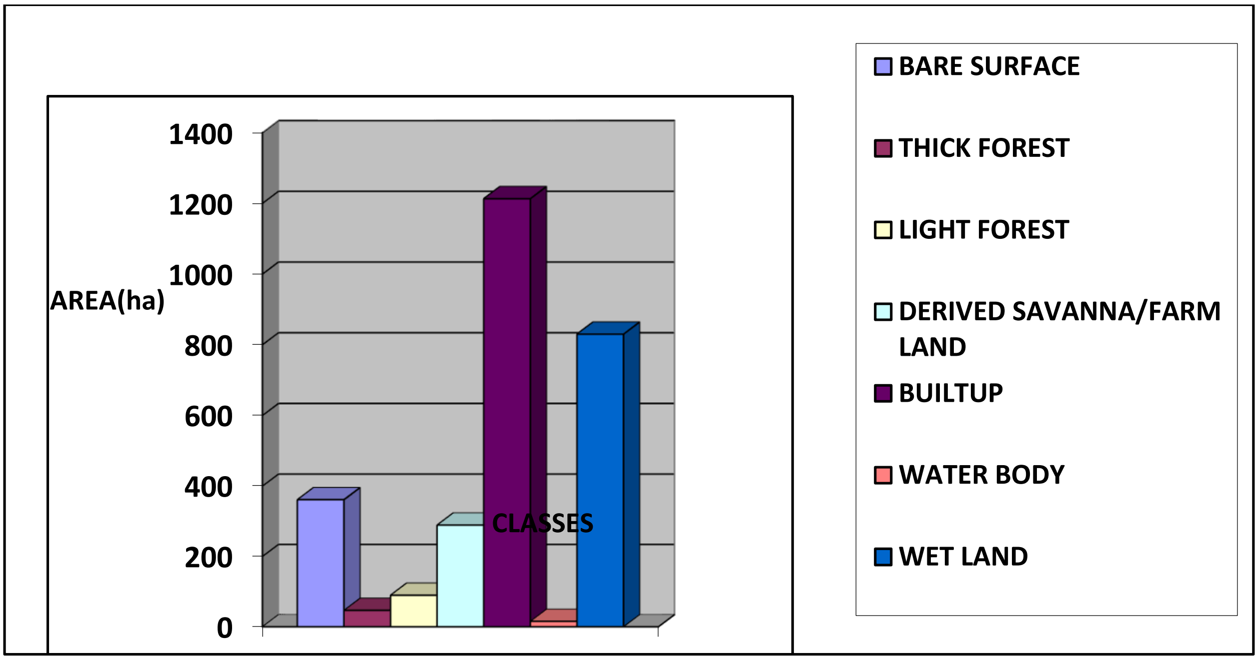

FIG 17: Histogram of 2021.

Table 8: Land use and Land Cover Statistics for Ibadan North West LGA. (From 2000 to 2021)

Categories	2000		2014		2021	
	AREA(HA)	AREA (%)	AREA (HA)	AREA (%)	AREA (HA)	AREA (%)
Bare surface	205.47	7.2	341.91	11.90	361.26	12.70
Thick forest	58.77	2.0	91.80	3.20	46.62	1.64
Light forest	87.93	3.0	55.26	1.90	89.50	3.15
Derived savanna/farm land	161.91	7.6	280.53	9.80	289.08	10.16
Built up area	1197.99	40.1	1211.22	42.40	1213.29	42.64
Water body	46.89	1.7	21.33	0.75	15.30	0.54
Wetland	1086.21	38.2	854.19	29.90	830.16	29.18
TOTAL	2845.17	100	2856.24	100	2845.17	100

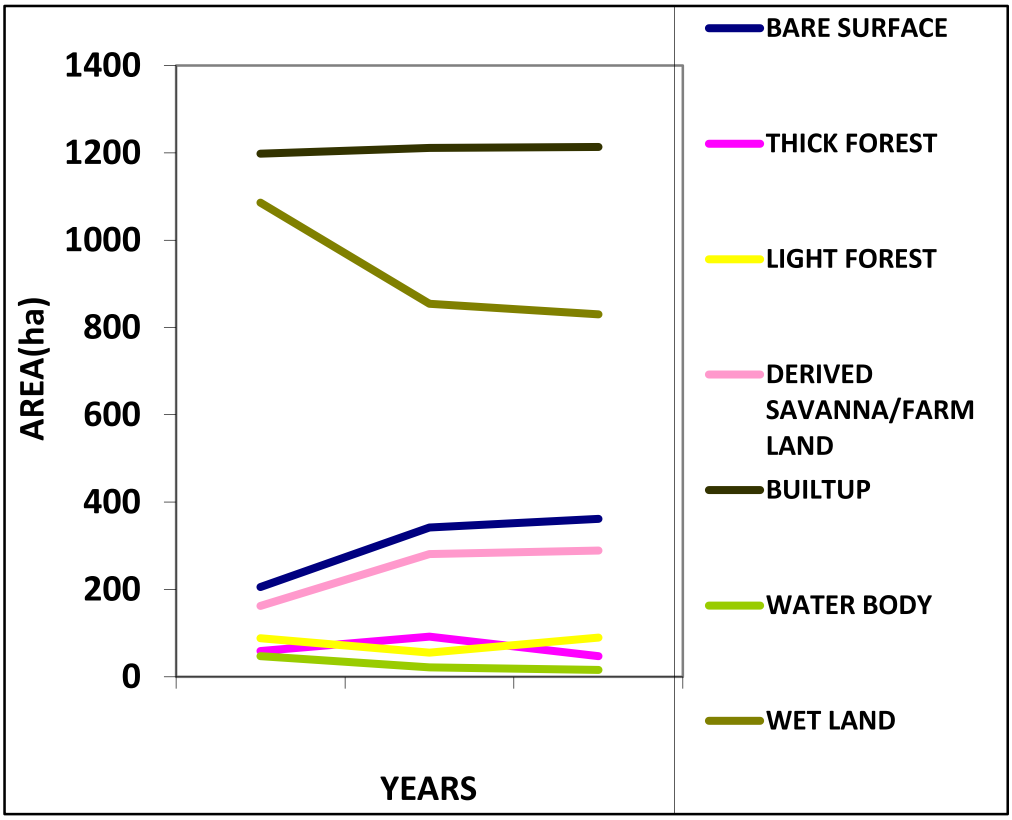

FIG 18: Trend of Classes between 2000, 2014, and 2020

The figures presented in fig 15 above represent the static area of each land use land cover category for each study year. Built-up was the dominant land use landcover class in 2000, taking about 40.1% of the total area followed by wetland which covers an area of about 38.2% of the study area. This may not be unconnected to the fact that Ibadan has long been regarded as one of the cities in the world with highest slums and with few industries.

In table 8, built-up covered the largest area with 42.4% of the total area followed by wetland that has 29.9%.

Change Analysis

The period of change analysis was from 2000 to 2014 based on the data available. Through image analysis and change detection analysis in IDRIS GIS, using image differencing the changes were measured and converted to vector GIS data for precise area measurements. The results of the changes are presented below.The table 8 equally reveals that the increase in built- up area from 40.1% to 42.4% in 2000 and 2014 respectively may be as a result of urban rural-urban drift and renewal policy of government of the State in recent times. From the maps derived from the Landsat images, it is observed that growth tilts towards the Eleyele dam.

For the projected change as shown in Table 9, the wetland seems to have decreased and this therefore suggests that encroachment on wetland will occur provided all this parameters are kept constant.Again, the water body is shrinking and there is a probability of it being covered with buildings if development is not monitored or controlled. It is therefore suggested that while people should be encouraged to build towards the suburbs to reduce compactness in the city by creating pulling factors, which are capable of pushing them away from the city Centre, and activities of man in the fringes should properly be monitored.

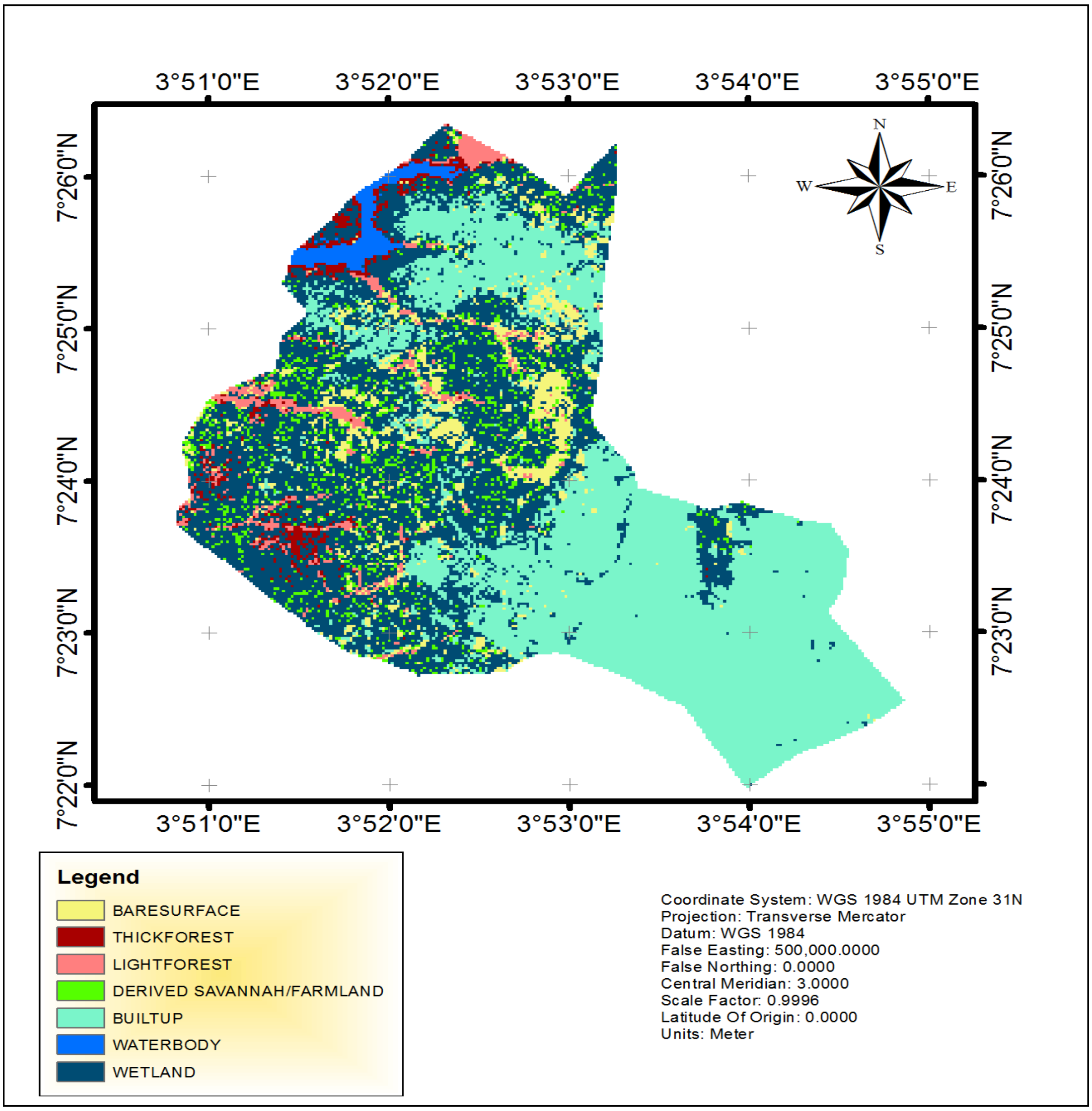

FIG 19: Supervised Classification of 2000.

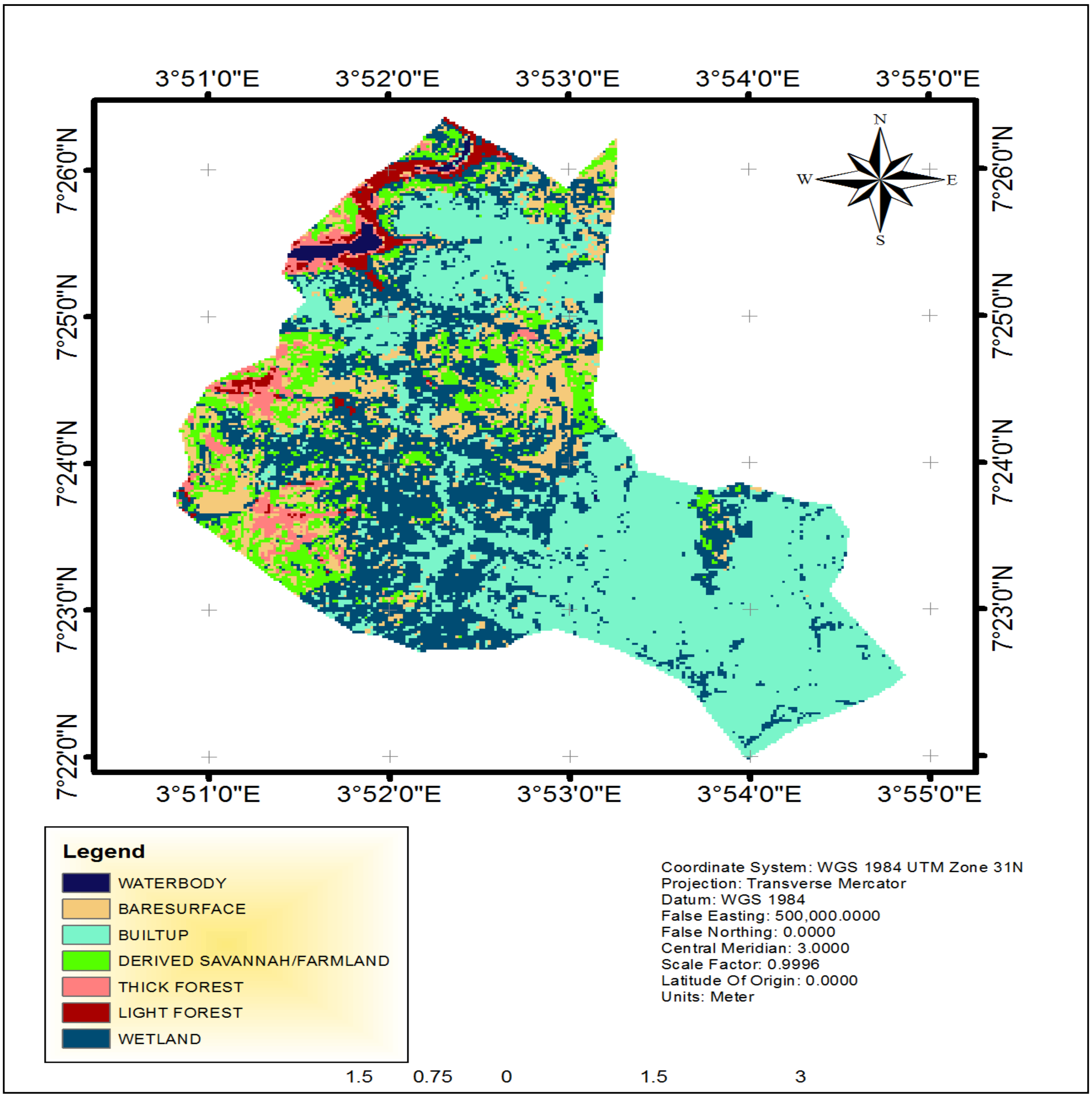

Fig 20: Supervised Classification 2014

Transition Probability Matrix

The TPM records the probability that each landuselandcover category will change to the other category. The matrix is produced by multiplication of each column in the transition probability matrix by the number of cell of corresponding landuse in the later image. For the 7 by 7 matrix in table 9, the rows represent the older landuselandcover category (2000), while column represent newer category.

Table 9: Probability Matrix

CLASSES	Built up	Wetland	Water body	Thick forest	Light forest	Farmland	Bare surface
Built up	0.9358	0.0000	0.0000	0.0000	0.0000	0.0542	0.0101
Wetland	0.0000	0.2694	0.0793	0.3788	0.2211	0.0514	0.0000
Water body	0.0000	0.0275	0.5472	0.0467	0.1313	0.0000	0.0000
Thick forest	0.0489	0.0056	0.0013	0.2839	0.0588	0.5498	0.0516
Light forest	0.0333	0.0304	0.0039	0.2835	0.1593	0.4392	0.0504
Farm land	0.1782	0.0065	0.0000	0.1248	0.0231	0.5982	0.0692
Bare surface	0.1785	0.0000	0.0000	0.0189	0.0242	0.5346	0.2438

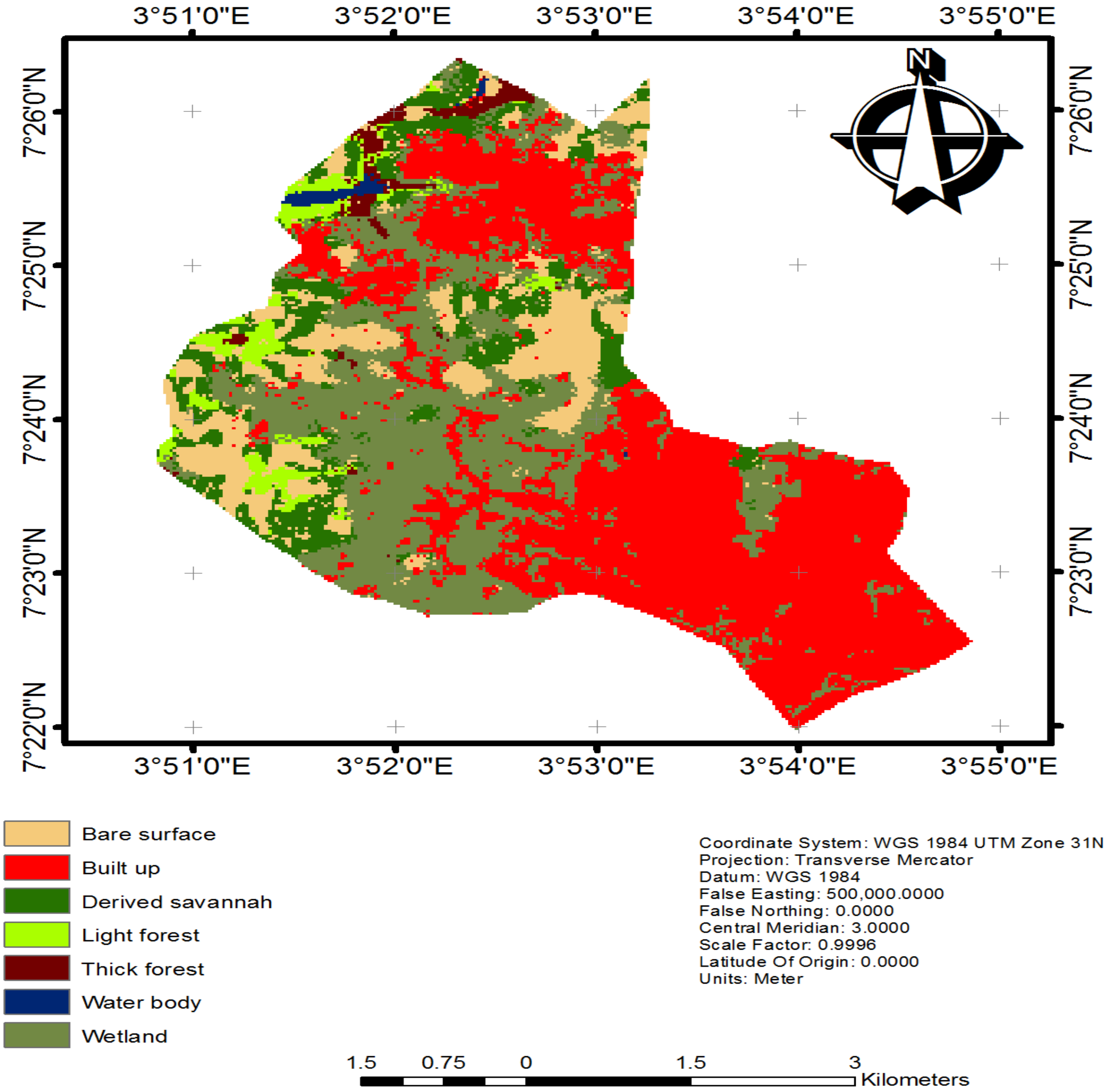

FIG 21: Prediction in 2021

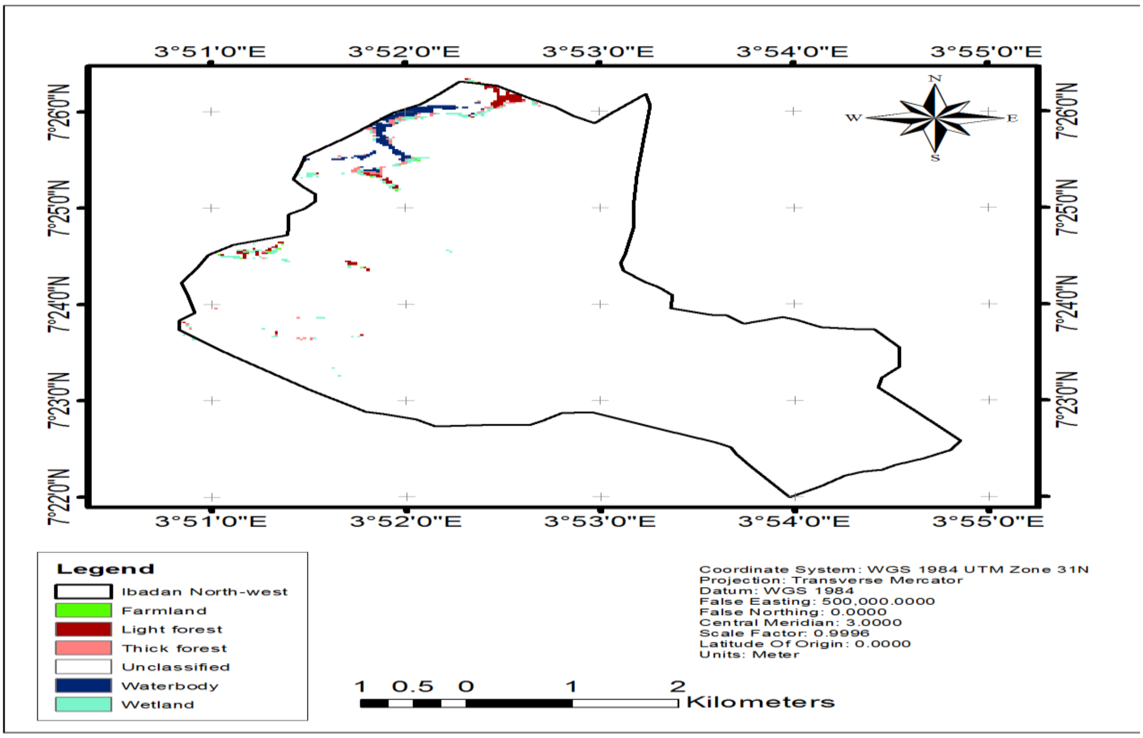

Fig 22: Contribution to Bare Surface.

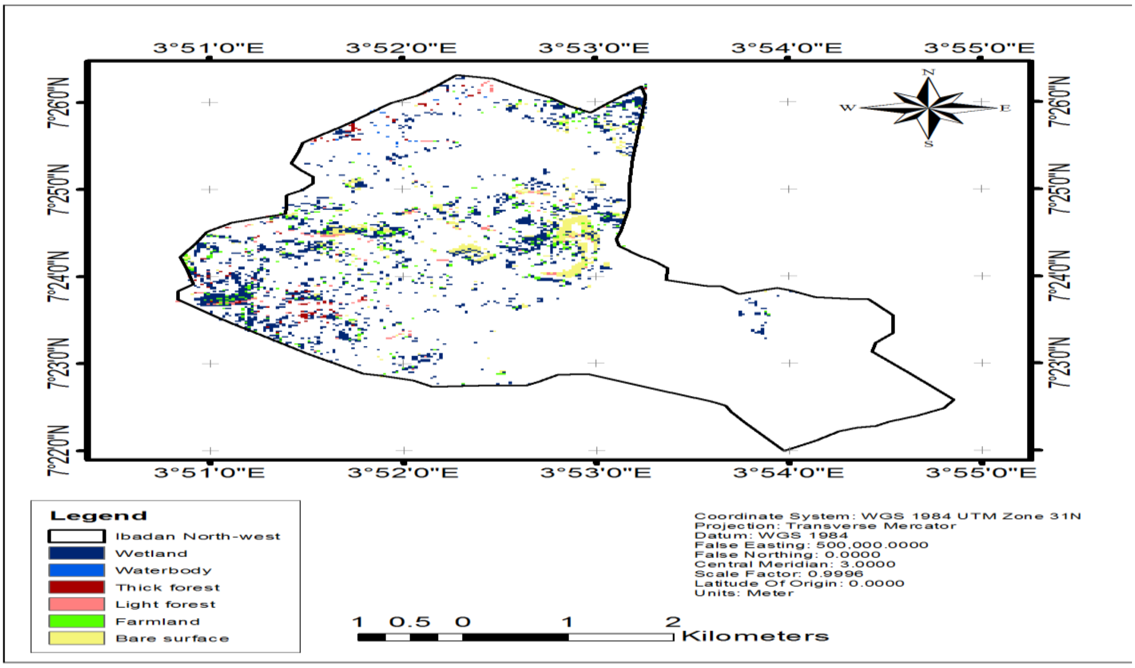

Fig 23: Contribution to Built-up.

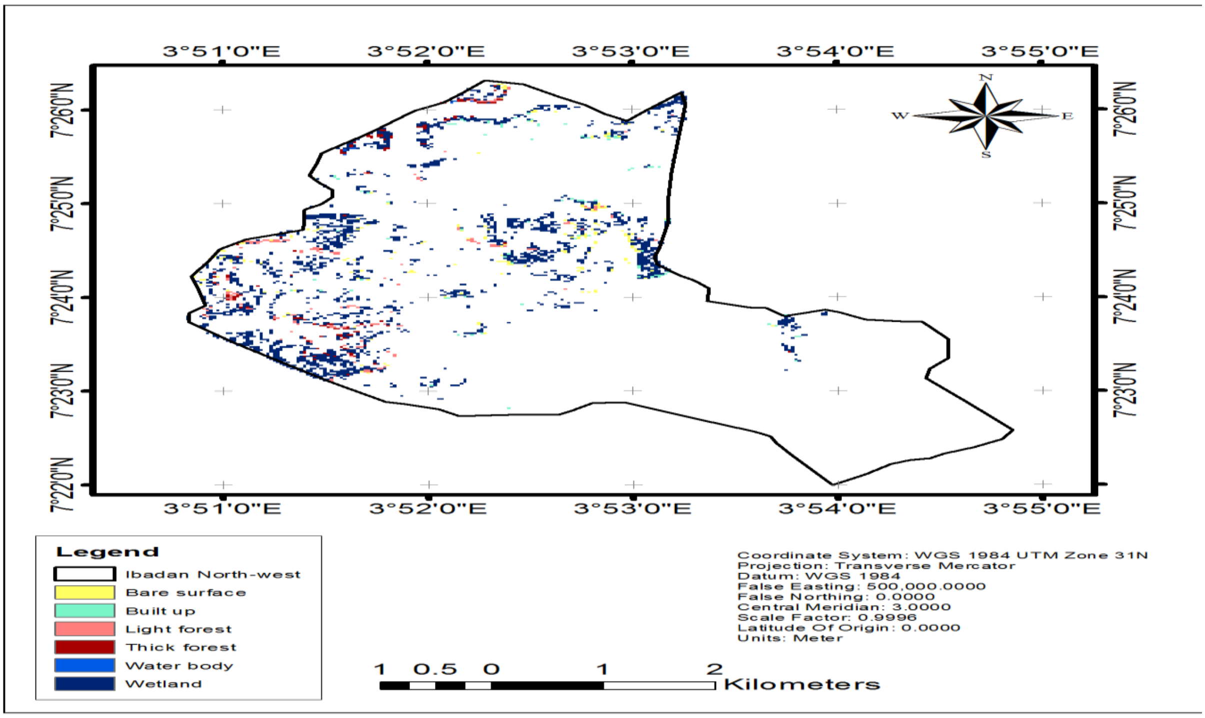

Fig 24: Contribution to Farmland.

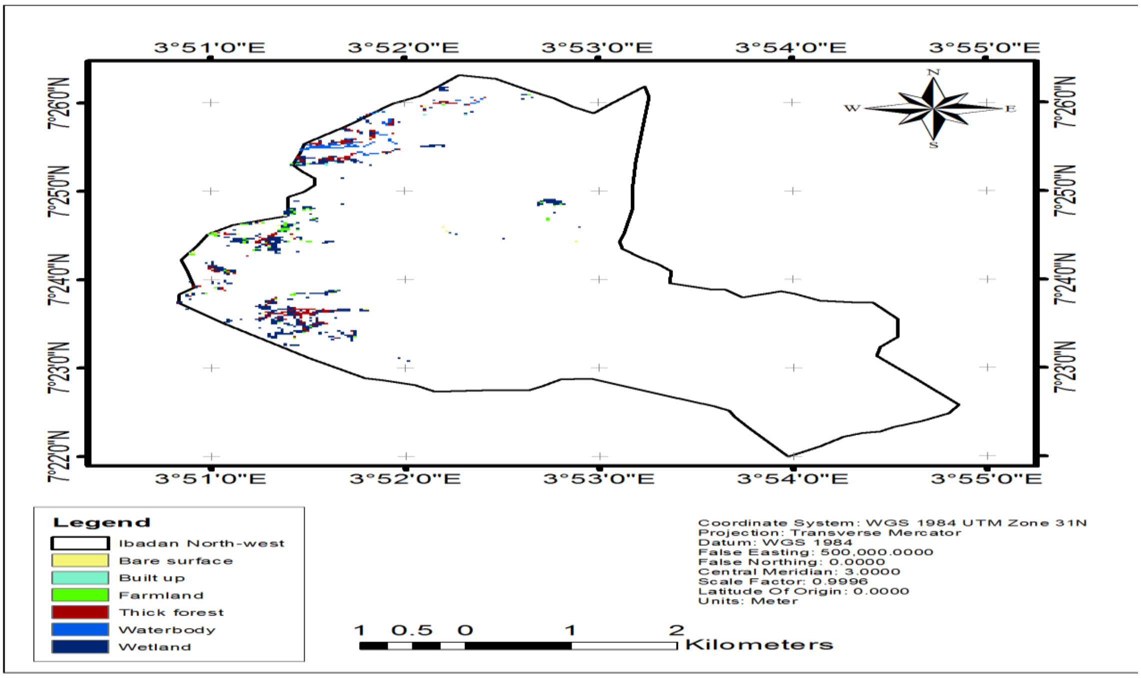

Fig 25: Contribution to Lightforest

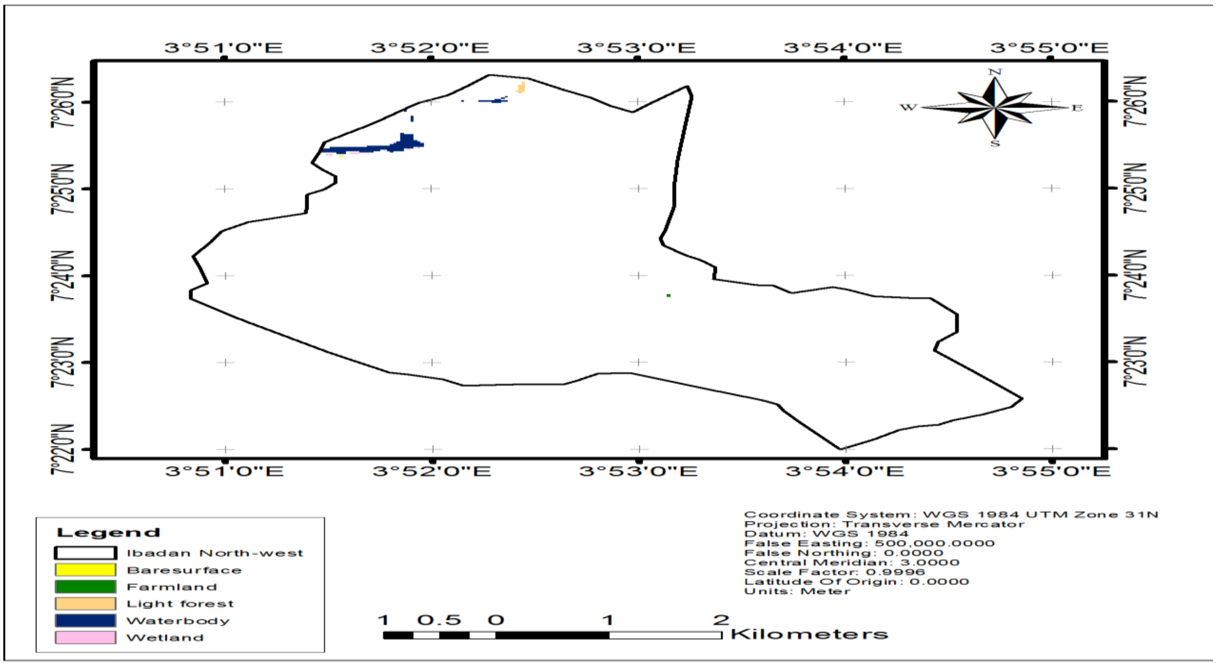

Fig 26: Contribution to Thick forest.

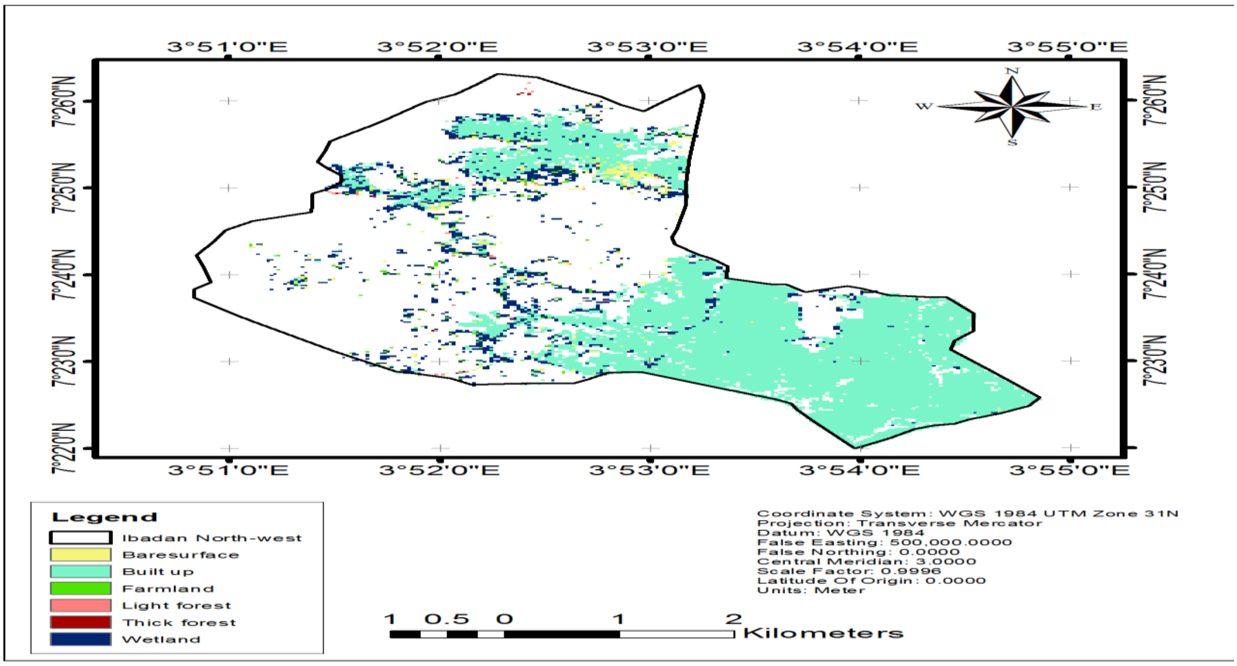

Fig 27: Contribution to Waterbody.

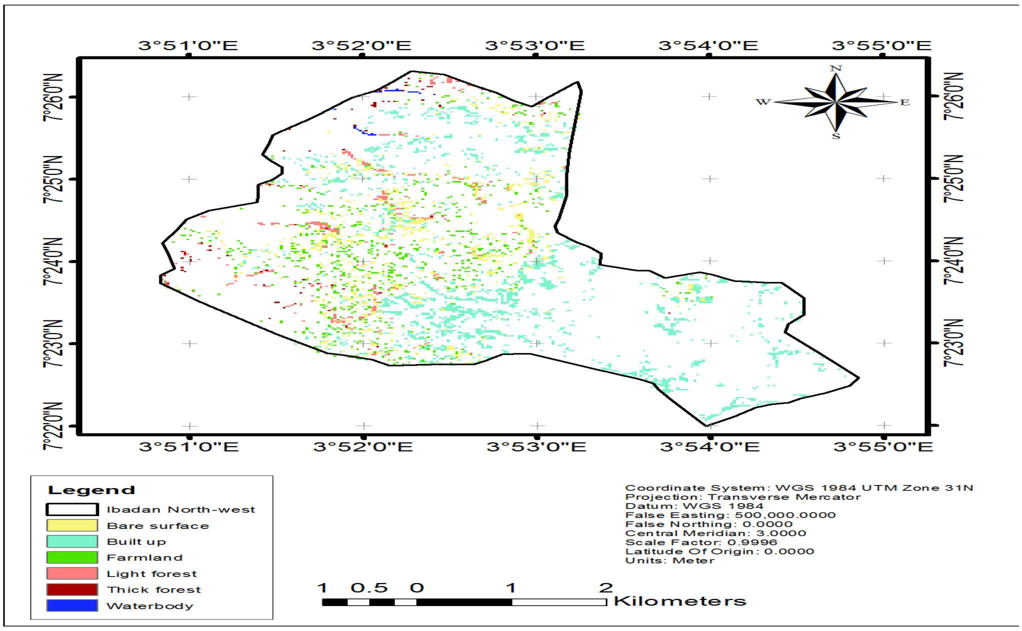

Fig 28: contribution to built up area

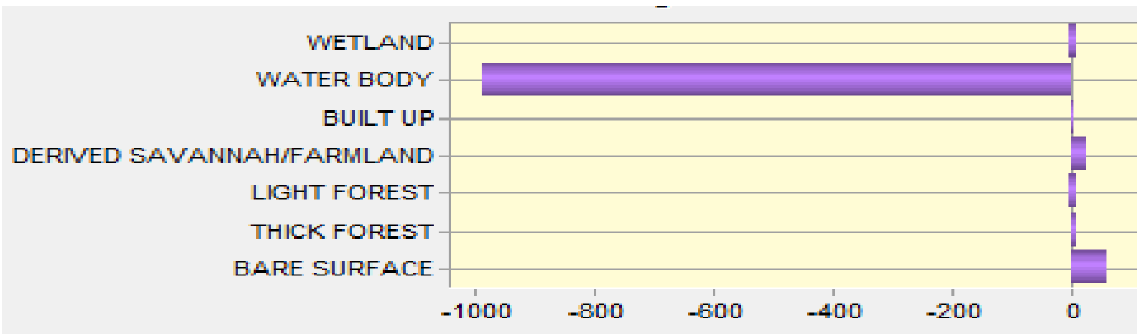

Fig 29: Contribution to Wetland.

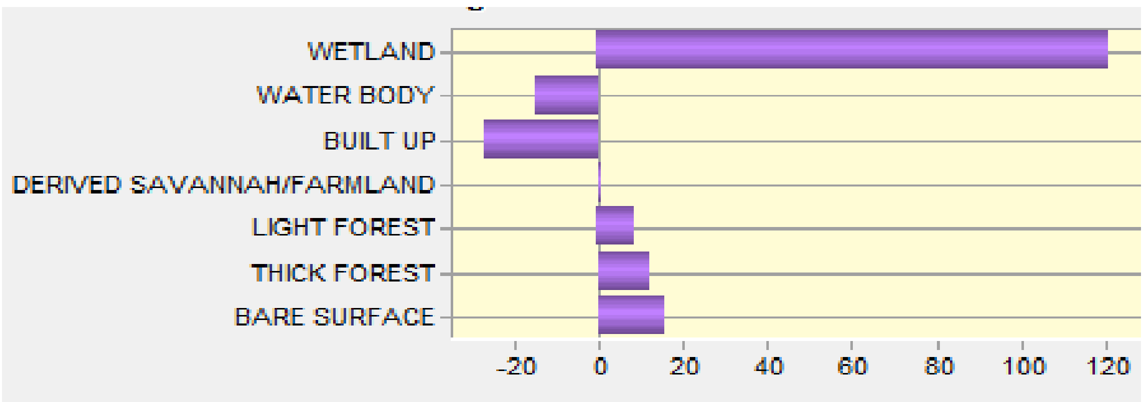

Fig 30: Contribution to change in Farmland.

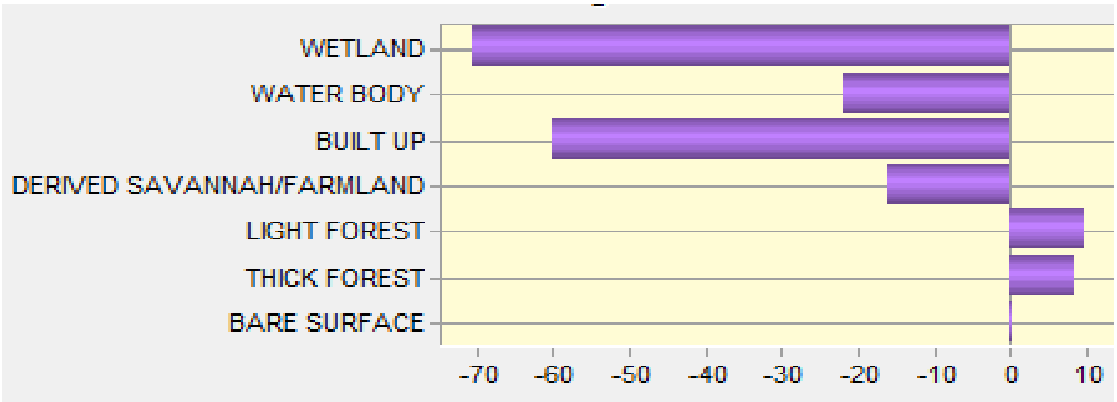

Fig 31: Contribution to change in Baresurface.

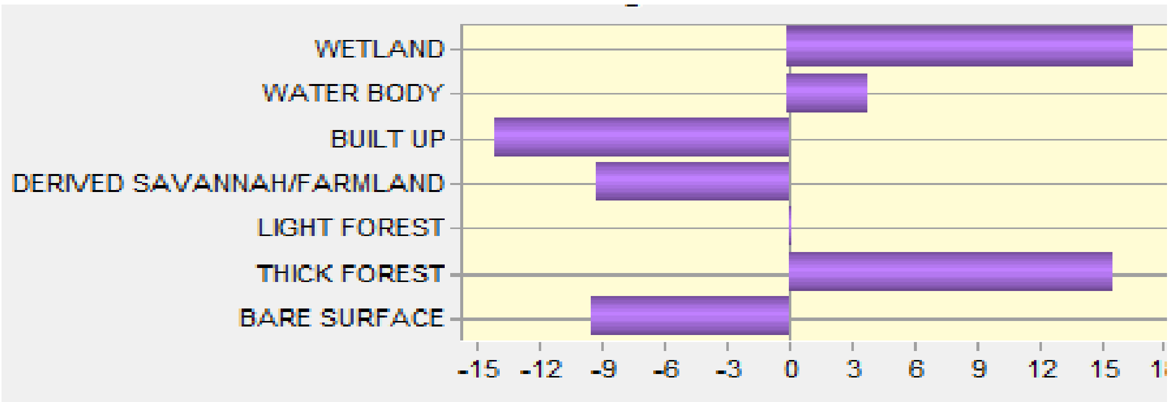

Fig 32: Contribution to change in Lightforest.

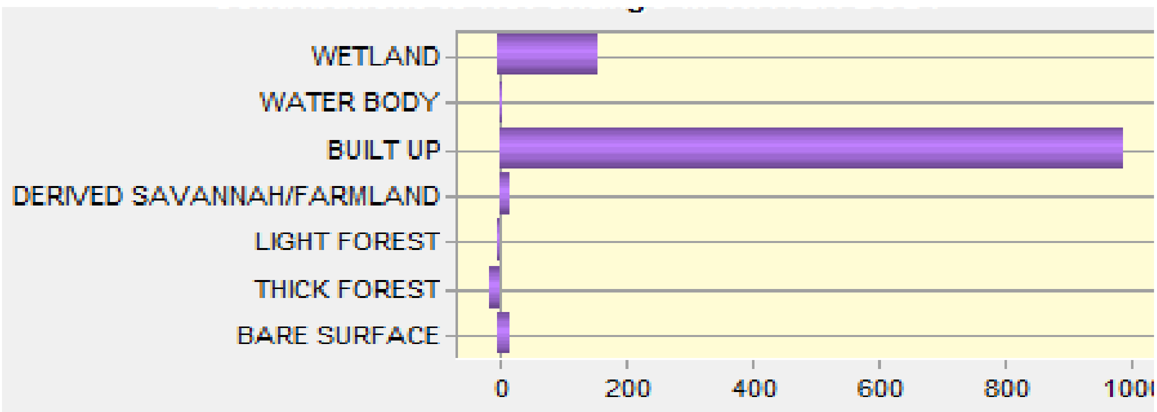

Fig 33: Contribution to change in Thickforest.

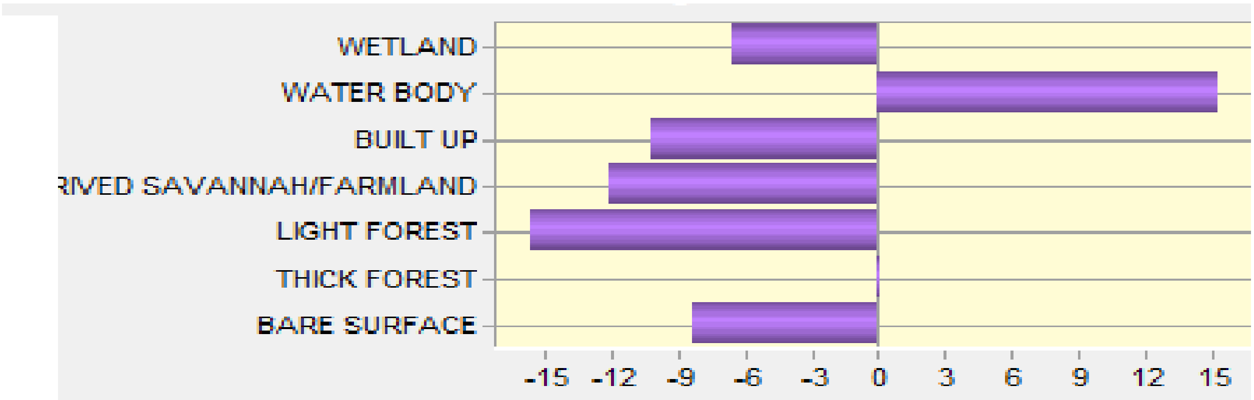

Fig 34: Contribution to change in bare surface

Conclusion

This study has shown that information gotten from satellite remote sensing and integrating it with GIS can play an important role in understanding the nature and extent of changes in land use and landcover where these changes are occurring and are been monitored in local scale. The change detection analysis integrated with the transition matrix and Cellular Automata Markov performed in the study allowed for the monitoring of landuse/landcover changes overtime and space. The analysis provided valuable insight into the nature and extent of changes that have taken place in Ibadan Northwest LGA from 2000 to 2014 and lays foundation for further study to be conducted that aims at modelling and predicting future changes.

Changes in landuse/landcover pattern have been identified by analyzing the multi- temporal Landsat images of 2000 and 2014 in a GIS platform. The quantitative evidences of landuse/landcover changes revealed the dynamic growth of Built – up areas. Conversion of riparian to thick forest represent the most prominent land cover change, the change difference was as high.

The trend and extent of urban change is likely to continue with the rapid development of infrastructure due to increasing population.

In order to alleviate the dramatic landuse/landcover change and adverse environmental impacts of urban expansion and increasing built up surfaces, which negates the principle of sustainable development, the current growth pattern needs to be managed through effective landuse/landcover planning and management. This would be useful to protect the fragile and important wetland and water body in the area and further reduce environmental degradation in the form of soil erosion and water stress.

In conclusion, present study of Ibadan Northwest LGA in Oyo State Nigeria from 2000 to 2014 shows change in the landscape as there is high growth in the built up area only within (14) fourteen years. Water bodies have been covered by riparian while wetland has reduced marginally and other classes are showing little or almost stagnant condition over time.

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ABOUT THE AUTHORS

Dr. Abiodun Olufemi Adebola

Department of Remote Sensing and GIS,

Federal University of Technology, Akure,

Ondo State.

collinola@gmail.com

Dr. Suleiman Abdulazeez Adegboyega,

Department of Remote Sensing and GIS,

Federal University of Technology, Akure,

Ondo State

adegboyega_s@yahoo.com

Dr. Ayo Emmanuel Olajuyigbe

Department of Urban and Regional Planning,

Federal University of Technology, Akure,

Ondo State.

Olajuyigbe03@yahoo.com

Mr. Sunday Olu Oladejo

Department of Remote Sensing and GIS,

Federal University of Technology, Akure,

Ondo State

Sundayoladejo001@yahoo.com