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URBAN SPRAWL ANALYSIS IN JALINGO METROPOLIS, TARABA STATE NIGERIA

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ABSTRACT

This study analyzed spatial and temporal land use /land cover change in Jalingo Metropolis, Taraba State, north east Nigeria. This was carried out with the use of land sat images from 1990-2015. Satellite images were obtained from the United State Geological Survey (USGS) database online resources. The images were georeferenced and processed. Supervised image classification technique was employed. Ground truthing field survey was carried out to complement information about the types of land use and land-cover classes in the area. The change detection and change matrixes of the classified satellite images were analyzed using percentage to see the rate of change in a simple form. Land use maps were obtained through supervised classifications of satellite imageries and presented in Tables. The findings of the study show that Jalingo Metropolis has witnessed unprecedented spatial growth over the years. The town has grown from 6.01km2 in 1990 to 55.7km2 in 2005 and 101.16 in 2015. This growth was as a result of change in the status of the metropolis from Local Government headquarters to state capital which brought about the establishment of government ministries and agencies, with wide range of opportunities. Despite the existence of master plan, implementation has not been satisfactory for a number of reasons. This has resulted in proliferation of haphazard and uncontrolled development (including slums and squatters), environmental degradation, lack of basic amenities and transportation problems within and around the town. The study recommends the need to update the urban database of Jalingo town using GIS and Remote Sensing techniques to plan and monitor urban land use changes in the area.

Keywords: Jalingo, Lamurde, Landuse, Master plan, Metropolis, Sprawl, Taraba state.

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Contribution/ Originality

This study is one of very few studies that maps urban sprawl in the study area. This helps to anticipate the likely danger of urban sprawl and the rate of urban expansion in the area.

1. INTRODUCTION

One of the greatest challenges of developing countries especially in Sub Sahara Africa is the increasing rate of urbanization and its attendant effects on the rural and urban environment. The It has been observed by the United Nations in 2009, that between 2007 and 2025 the annual urban population increase in developing nations is expected to be over 53million (or 2.27 percent) compared to 3 million (or 0.49 percent) in developed nations [1]. Urbanization in Sub Sahara Africa particularly Nigeria is characterized by development of sprawl. Urban sprawl can be defined as 'uncoordinated growth' and expansion of a community without concern for consequences or environmental impact [2]. It can also be defined as the scattering of new development on isolated tracts, separated from other areas by vacant land [3]. Urban sprawl involves the construction of residential and commercial buildings in rural areas or otherwise undeveloped land at the outskirts of a city Okeke [2]. Omole [4] defined Urban sprawl as a formless dispersal of congested urban area with little or no regard for the inter-relationship of

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such factors as transportation, employment, health, and recreational needs. Sprawl in simple terms is just the spreading out of a city and its suburbs over more and more rural land at the periphery of an urban area [5].

Thus, urban sprawl is often uncoordinated and extends along the fringes of urban area. More often than not, sprawl invades prime agricultural and resource land in the process. This leads to the development of land in a fragmented and piecemeal manner with much of the surrounding spaces undeveloped or in uses with little functionality. The increases in human population result in demand for new housing, schools, hospitals and transportation networks among others, leading to urban sprawl.

Urban sprawl is most often found in low density areas that are separated from the major urban area by large tracts of homogenous land. This necessitates the need for large transportation networks and greater dependence on automobiles which produces more air pollution. As new roads are put in place, valuable farmlands are left unprotected from commercial and residential developers [6]. Other challenges of urban sprawl include climate change, destruction of vegetation and agricultural lands and pollution of air, surface and ground water sources.

Jalingo town has witnessed remarkable expansion, growth and developmental activities such as building of residential and commercial structures and road construction since its inception in 1991. The town being the state capital and largest town in the state has a lot of scope for development and urban growth. The town's population is expected to increase to over 200,000 in 2020. With increasing population and unprecedented growth of urban area, the town is undergoing unwanted changes. This has resulted in increased land conversion, modification and alteration in the status of her land cover over time without any detailed assessment and monitoring of these changes. This makes it imperative to examine this status and changes over time with a view to detecting the land conversion rate, monitor and predict future land use changes for effective urban development planning.

Mapping urban sprawl is one of the most important and successful applications of remote sensing. Unlike the traditional surveying and mapping methods, remote sensing has proven to be a cost effective and technologically sound method of analyzing urban sprawl [7-9]. Remote sensing data are very important in studies of land use changes where updating of information is often tedious and time-consuming. The monitoring of urban development is mainly to find out the type, amount and location of land use conversion that has occurred Yeh and LI [10]. Lin, et al. [11] observed that monitoring and simulation of urban sprawl and its effects on land use patterns and hydrological processes in urbanized watersheds are essential in land use and water resource planning and management. Thus, one of the prerequisite for understanding urban sprawl is successful land use change detection [12] a process that can be achieved through the use of remotely sensed data. Mapping the expansion of urban area is one of the most important and successful application of remote sensing. Remote sensing using satellite data could deliver periodic large coverage, less expensive and accurate mapping of urban sprawl. This study uses remote sensing data of Jalingo area for the period 1990 to 2015 to examine land conversion rate and the changes that have taking place so as to predict possible changes that might likely take place in the next 25 years in the study area. This helps to anticipate the likely danger of urban sprawl and the rate of urban expansion in the area. This will assist in better planning of the expansion that will reduce the negative impact that might arise later.

2. MATERIALS AND METHODS

To achieve the objectives of this study, three satellite images were obtained from the United State Geological Survey (USGS) database online resources. Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM+) were used in the mapping of urban growth analysis of the study area. Satellite imageries for the years 1990, 2005 and 2015 were used.

The Geo- referencing properties of all the images were different, Re-sampling operation was performed on the imageries to modify their resolution and properties to that of the TM image acquired. The images were georeferenced to the Universal Transverse Mercator (UTM, zone 32°N) Minna datum. Atmospheric correction was applied to remove the dust and haze effect from each image by using the dark-object subtraction method [13]. Subset image was created for subsequent classification.

Supervised image classification technique was employed in this study. Ground truthing field survey was carried out to complemented information about the types of land use and land-cover classes in the area. The false color composite image was classified using maximum likelihood classification algorithm. Training sites were chosen to represent land cover classes, such as vegetation, built up area, water body, bare surface and rock outcrop. The Maximum Likelihood Classifier (MLC) was the algorithm used for the clustering process. The change detection and change matrixes of the classified satellite images were analyzed using percentage to see the rate of change in a simple form. Land use maps were obtained through supervised classifications of satellite imageries and presented in Tables and charts. Calculation of the area in hectares and percentage of urban growth was carried out. The maximum likelihood classification, Marcov chain analysis and cellular Automata techniques were used to predict change. These three methods were used to identify changes in the urban growth development in the study area. The comparison of urban growth assisted in identifying the percentage change, trend and rate of changes between 1990, 2005 and 2015.

3. RESULTS AND DISCUSSION

The classification results of the images show that Jalingo Metropolis has witnessed unprecedented spatial growth over the years. In 1990, just before the creation of the state, the spatial extent of Jalingo Metropolis was 6.0073 km^2. Jalingo then was a Local Government Area headquarters and has not attained the status of a state capital. It became a State Capital when the state was carved out of the defunct Gongola State in 1991. The trend of urban growth shows that the built - up areas experienced growth of about 27% (49.6497 square kilometers) between 1990 and 2005 (Table 1). This growth was as a result of change in the status of the metropolis from Local Government headquarters to state capital which brought about the establishment of government ministries and agencies. The search for jobs in the metropolis from the rural areas also added to the expansion of the metropolis. There was further increase in the built up areas of 23% between 2005 and 2015.

Table-1. Land use Land cover distribution (1990, 2005 and 2015)

Classes	Area (km^2) 1990	Area in Percentage	Area (in km^2) 2005	Area in Percentage	Area (in km^2) 2015	Area in Percentage
Rock out crop	65.3625	33.29%	36.489	18.99%	2.2505	1.18%
Vegetation	104.8639	53.41%	85.4614	44.48%	45.6827	23.86%
Build Up	6.0073	3.05%	55.657	29.97%	101.1644	52.84%
Bare Surface	12.6694	6.45%	7.3665	3.83%	35.2197	18.39%
Water Body	7.4511	3.79%	7.1501	3.72%	7.1412	3.73%

Source: Data analysis, 2016

Table-2. Post Classification Change Analysis of Jalingo Town (1990, 2005 and 2015)

Class	1990/2005 Area (km^2)	Area Change in Percentage	2005/2015 Area (km^2)	Area Change in Percentage
Rock	-28.8735	-14.3	-34.2385	-17.81
Vegetation	-19.4025	-8.93	-39.7787	-20.60
Build Up	49.6497	26.92	45-5074	22.87
Bare Surface	-5.3029	-2.62	27.8532	14.54
Water Body	-0.301	-0.07	-8.9	0.01

Source: Data analysis, 2016

Although the percentage increase in the buildup areas has reduced from 27% to 23%, the buildup areas have experienced an increase of 45.5074 km^2. During this period (2005 to 2015), many projects were embarked upon after the creation of the state. Some of these projects include the Jolly Nyame Stadium, Techno – Bat Housing Estate, Electricity Transmission Station, Jalingo Modern Market, School of Nursing and Midwifery, Specialist

Hospital and Taraba State University among others. These projects were complimented by the construction of township roads such as Donga road, T.Y Danjuma road, Jalingo byepass road, Pharmacist Danbaba Suntai road and recently the Kona dual express road. Other land uses were greatly affected by the growth taking place in the area. The classification results show that vegetation in the area has a consistent decrease in relation to build up areas while the remaining lands uses (Bare Surface, Rock out Crops, and Water Body) show irregular pattern (see Table 1 and 2). Figure 1 – 4 are land use maps showing the pictorial representation of the pattern of change in the study area.

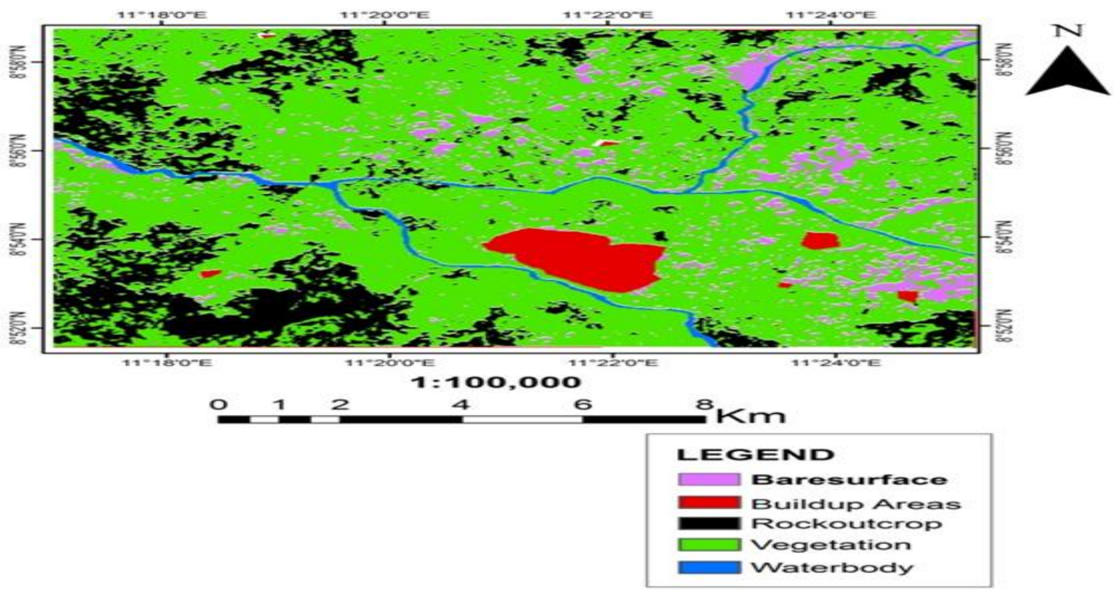

Figure-1. Land Cover Map of 1990.

Source: Proessed image, 2016

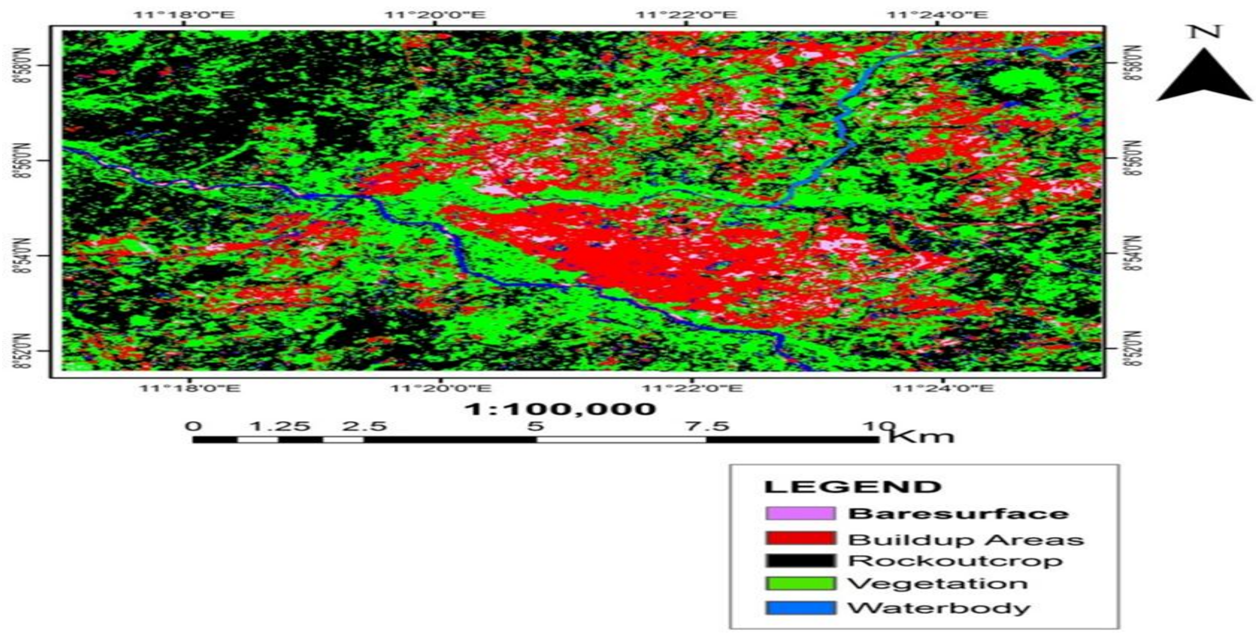

Figure-2. Land Cover Map of 2005.

Source: Processed image, 2016

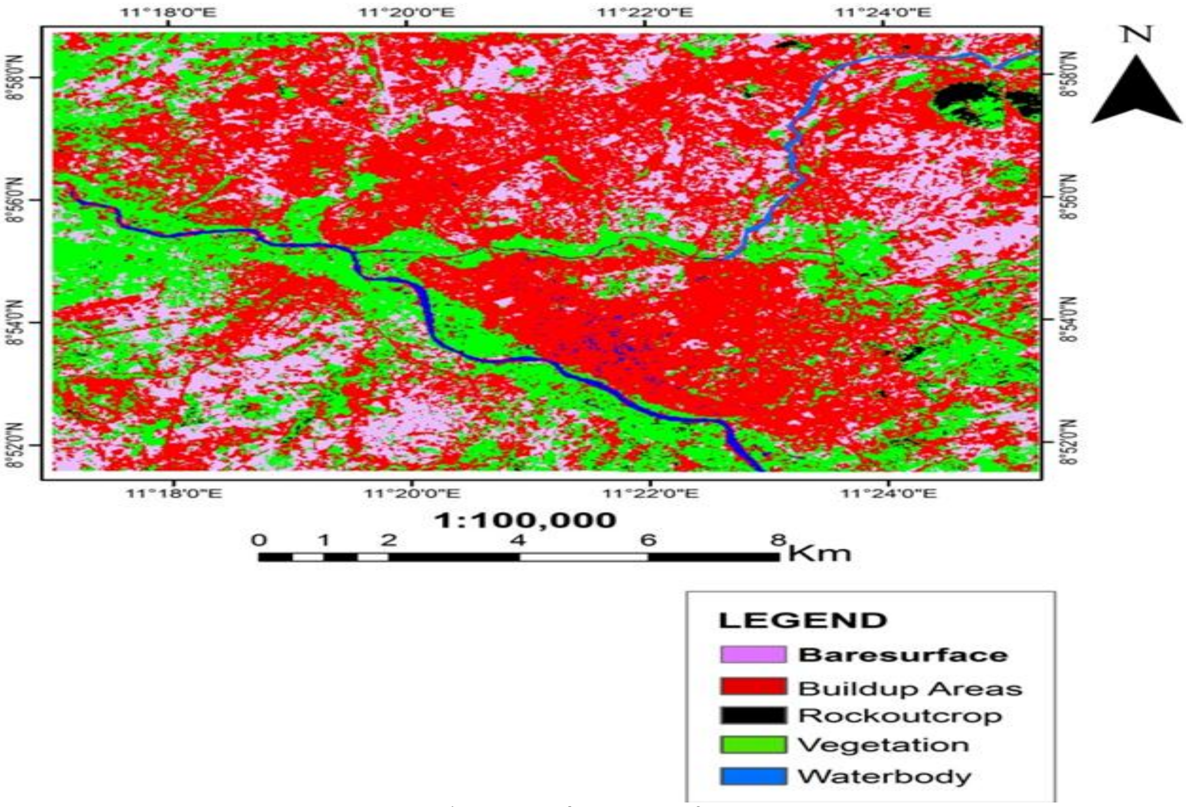

Figure-3. Land Cover Map of 2015

Source: Processed image 2016

Prediction of Urban Growth in Jalingo Metropolis

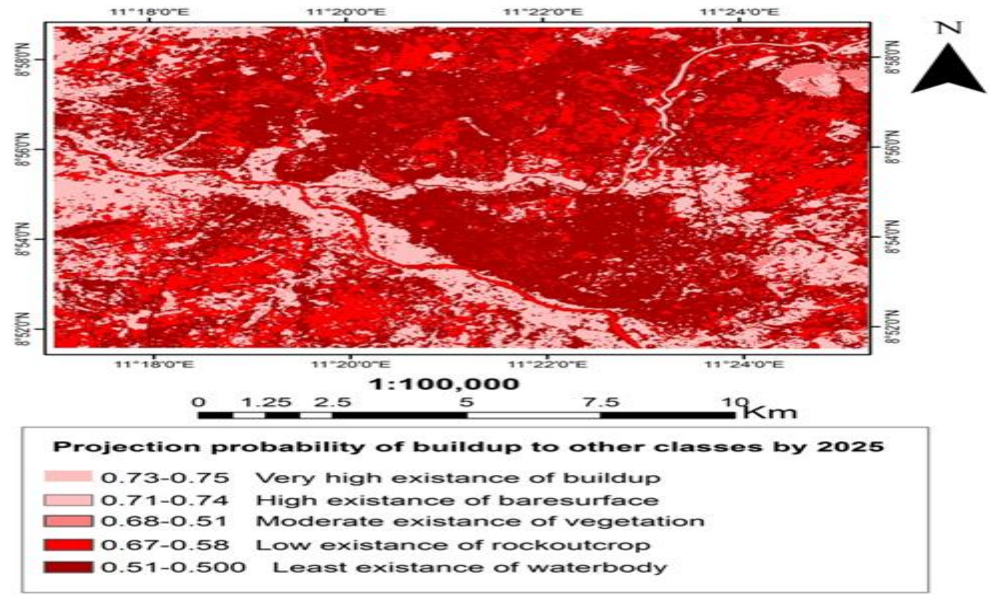

Fig-4. Projection of buildup areas by 2025

Source: Processed image 2016

4.2. The Transition Probability Matrix

The transition probability matrix records the probability that each land cover category will change to the other category. This matrix is produced by the multiplication of each column in the transition probability matrix by the number of cells of corresponding land use in the later image.

For the 5 by 5 matrix table presented below, the rows represent the older land cover categories and the column represents the newer categories. Although this matrix can be used as a direct input for specification of the prior possibilities in maximum likelihood classification of the remotely sensed imagery, it was however used in predicting land cover of 2015.

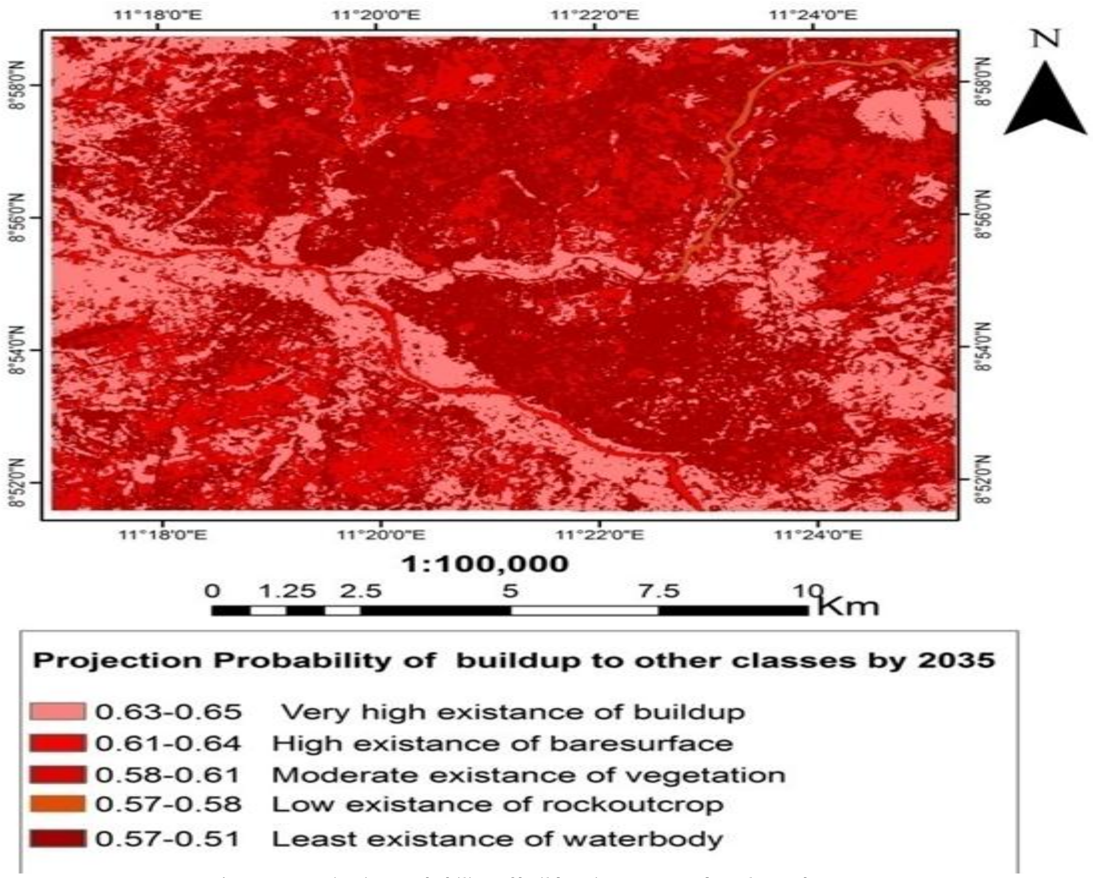

Figure-5. Projection probability of build up in 2015 to other classes by 2035

Source: Processed image 2016

Table-3. Transitional Probability Table derived from the land use land cover map of 2015

	Land use	CL1 Rock outcrop	CL2 Vegetation	CL3 Buildup	CL4 Bare surface	CL5 Water body
CL1	Rock	0.0064	0.1416	0.6508	0.2624	0.0094
CL2	Vegetation	0.0062	0.1392	0.6459	0.2689	0.0097
CL3	Buildup	0.0021	0.0577	0.6140	0.2742	0.0120
CL4	Bare surface	0.0019	0.0565	0.5893	0.2908	0.0115
CL5	Water body	0.0039	0.1618	0.5739	0.2549	0.0254

Source: Data analysis, 2016

Row categories represent land use land cover classes in 2015 whilst column categories represent 2035 classes. Rock outcrop has 0.0064 probability of remaining Rock outcrop and 0.6508 probability of changing to Buildup in 2035. This shows reduction, with a probability of change which is much higher than stability. Vegetation has 0. 6140 probability of changing into Buildup in 2035, which shows that there might be a high level of instability in Vegetation. Built-up during this period has a probability as high as 0.6140 to remain as built-up in 2035 which signifies stability. Bare surface has 0.2908 probability of remaining Bare surface and 0.5898 probability of changing into Built-up in 2035. This therefore shows an undesirable reduction, there might likely be high level of instability in Bare surface during this period. Water body which is the last class has 0.0133 probability of remaining as water body and 0.5739 probability of changing to Buildup in 2035.

Although Jalingo had a master plan, the inability of the master plan to function as an effective development control tools calls for its revision. Plots of cultivated land can be found on any vacant land and on areas close to small rivers or streams within and immediately surrounding the city. The Jalingo byepass road generated the greatest urban sprawl in the area, followed by the Nassarawa – Mile six roads and Karofi – ATC roads. The factors driving urban sprawl in the study area include demography, local topography, socio-economic factors and government policies.

5. DEMOGRAPHY

During the period covered by this study, over 150,000 persons have been added to the population of Jalingo. The growth of the present resident population in Jalingo town and environs is affected by economic growth as State capital, in addition to the natural growth rate. People are migrating into the area due to crisis caused by Boko Haram insurgency in the North east region. The forecasts are based on assumed growth rates which vary for each 5 year period. The population growth in the next 20 years is estimated and presented in Table 4.

Table-4. Population projection in the study area

YEAR	PROJECTED POPULATION
2015	227, 406
2020	266, 841
2025	322, 268
2030	367, 411
2035	429,548

Source: Oruonye [14]

This increase in population growth necessitated the development of more residential buildings, increased demand for social amenities and access routes. In other to reduce overcrowding and open up new spaces, roads were constructed to link the neighbourhoods. The roads construction were thus carried out on agricultural lands.

6. CONCLUSION

Urban growth in most developing countries has taken the form of sprawl. Urban sprawl plays a significant role in positive and negative development of urban cities and land use changes. In this study, process of land use change in Jalingo metropolis during 1990, 2005 and 2015 was investigated and mapped to show the trend. The findings of the study show that Jalingo Metropolis has witnessed unprecedented spatial growth over the years. The town has grown from 6.01km^2 in 1990 to 55.7km^2 in 2005 and 101.16 km^2 in 2015. This growth was as a result of change in the status of the metropolis from Local Government headquarters to state capital which brought about the establishment of government ministries and agencies, with wide range of opportunities. The change in functionality of the town as important trade and administrative centre encourage migration in the area. This increases the demand for land for settlement purpose and urban construction. The findings of the study show that these demand for settlement and urban construction brought changes in land use which result into development of sprawl in the area. Despite the fact that Jalingo town has a master plan (2000 to 2015) which is under review at the moment, its implementation has not been satisfactory for a number of reasons. This has resulted in proliferation of haphazard and uncontrolled development (including slums and squatters), environmental degradation, lack of basic amenities and transportation problems within and around the town. The present continuing urban encroachment of the flood plains in the area is a major source of concern because of the increasing incidence of flood disaster in the area. There should be a firm and stiff legal actions against violators of flood buffer zones regulations in the area. There is need also to update the urban database of Jalingo town using GIS and Remote Sensing techniques to plan and monitor urban land use changes in the area.

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Contributors/Acknowledgement: All authors contributed equally to the conception and design of the study.

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