Implications of Land Use and Land Cover Dynamics on Arable Lands in Jalingo Region, Nigeria: Remote Sensing and GIS Approach

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Abstract

This study investigates the pattern of land use and land cover dynamics in Jalingo region from 1973 to 2009 and highlights its implications on arable landscapes. Satellite images were analyzed to map and detect changes in the land cover using ArcGIS 9.3 and ERDAS Imagine 9.2 software. Considerable land cover change has been recorded in the study area with arable lands declining by about 85% from the initial value of 200, 771.2 hectares in 1973 to 29, 675 hectares in 2009. This entails that approximately 5, 423 hectares of arable lands is lost annually to other uses, which suggests that the whole of natural vegetation could be entirely wiped out in the next 30 years, if no direct and urgent intervention measure is put in place. The observed pattern of change in arable lands has multifarious implications on the region itself in particular and the global environmental sustainability in general. Obviously, the scenario has set in motion a chain of environmental, social, and economic consequences ranging from hazards like incessant soil erosions and floods; loss of biodiversity; food scarcity etc that are common phenomena in the region. The situation also portends a great danger of the vulnerability of climate consequences such as greenhouse effects, urban heat island effects, and global warming. This calls for proactive approach and deliberate efforts by the government and the inhabitants to rescue the threatened and fragile environment from total collapse. One of the short term measures that could be adopted is to embark on massive tree plantations in the area.

Keywords: Implications, Land use, land cover, Arable lands, Jalingo

Introduction

One of the greatest impacts of man on the environment is seen through transformations in land use-land cover (LULC). Because of the multifarious implications this has on man and the environment, researches have been devoted to its study by various authors (DeGloria 1985, Serra et al, 2008 and Geri et al, 2010) with a view to assessing its impacts and proffering possible solutions. Multiple temporal remotely-sensed data provides an effective and accurate evaluation of this impact (Bakr et al, 2010). This is done through timely and accurate detection of earth's surface features using satellite imageries, which provides a better understanding of the interactions between human and natural phenomena to better manage and use resources. It has been observed that remote sensing images are very useful in mapping and detecting changes in land cover (Sing et al, 2001).

Interestingly, Landsat satellite which has been in existence since 1972 provides data for land cover mapping with ease. Furthermore, the decision to make Landsat products available through GeoCover and the United States Geological Survey's (USGS) websites has provided free access to all Landsat holdings, offering added opportunities for land cover classification using Landsat imageries (Xu et al 2000). The authors took advantage of these dataset in this research to study the changing dynamics of land use-land cover of Jalingo region with a view to highlighting its implications on the agricultural landscapes.

Recently, there has been a report by Zemba (2012) of rapid growth in the population and sharp increase in urban expansion of Jalingo city due to change in its status to a state capital. This change made it a nucleus of growth for the surrounding areas thereby receiving high influx of population. This has resulted to significant land use-land cover change with urban or built-up land areas increased by over 500% over 18 years from the year the state was created (1991-2009).

Appreciable effort was made by Zemba (2012) to characterize the land cover conversions in Jalingo. However, the spatio-temporal dynamics of arable landscapes under rapid urbanization was described without adequate quantitative measurements to show the implications for the existing land use planning and management with regards to sustainability. The objective of this research is to analyze quantitatively the land use and land cover dynamics in Jalingo region with a view to highlighting the implications of this on the existing arable lands and food security.

Jalingo region, the study area is situated between latitudes 8^0 50' and 8^0 58'North of the equator and Longitudes 11^0 17' and 11^0 26'East of the Greenwich Meridian (Fig 1). It has a gently rolling topography with altitude ranging from 305 to 610 meters above sea level. To the south east of Jalingo, the land rises to a peak of about 914 meters which forms the watershed for River Lamurde and other streams that drain into River Benue. There are stretches of hills to the north and east including Jalingo hill, Hosere hill, Jauro Ashe hill, and Dambature hills ranging from the heights of 323 to 349 meters. These hills form interesting features in the landscape of Jalingo city (Ilesanmi, 1994). The city is sloppy in nature, hence making it self-draining to River Lamurde.

The climate of the area is a tropical Sudan type with two distinct seasons- wet and dry seasons (Jatau, 1993). The wet or rainy season commences in April and ends in October with an average annual rainfall value of about 930mm. The dry season, which is characterized by dry dust-laden wind (harmattan), is experienced in the area between the months of November and March. The minimum temperature of 13^0C was recorded in the months of January and the maximum can rise to as high as 42^0C usually in the months of April and May. The low temperature in January leads to low relative humidity of between 10–30%. However, this changes to about 80–90% in the wet season. The variations in the climatic elements as discussed above plays a great role in influencing agricultural practices and the general lives of the inhabitants of the area.

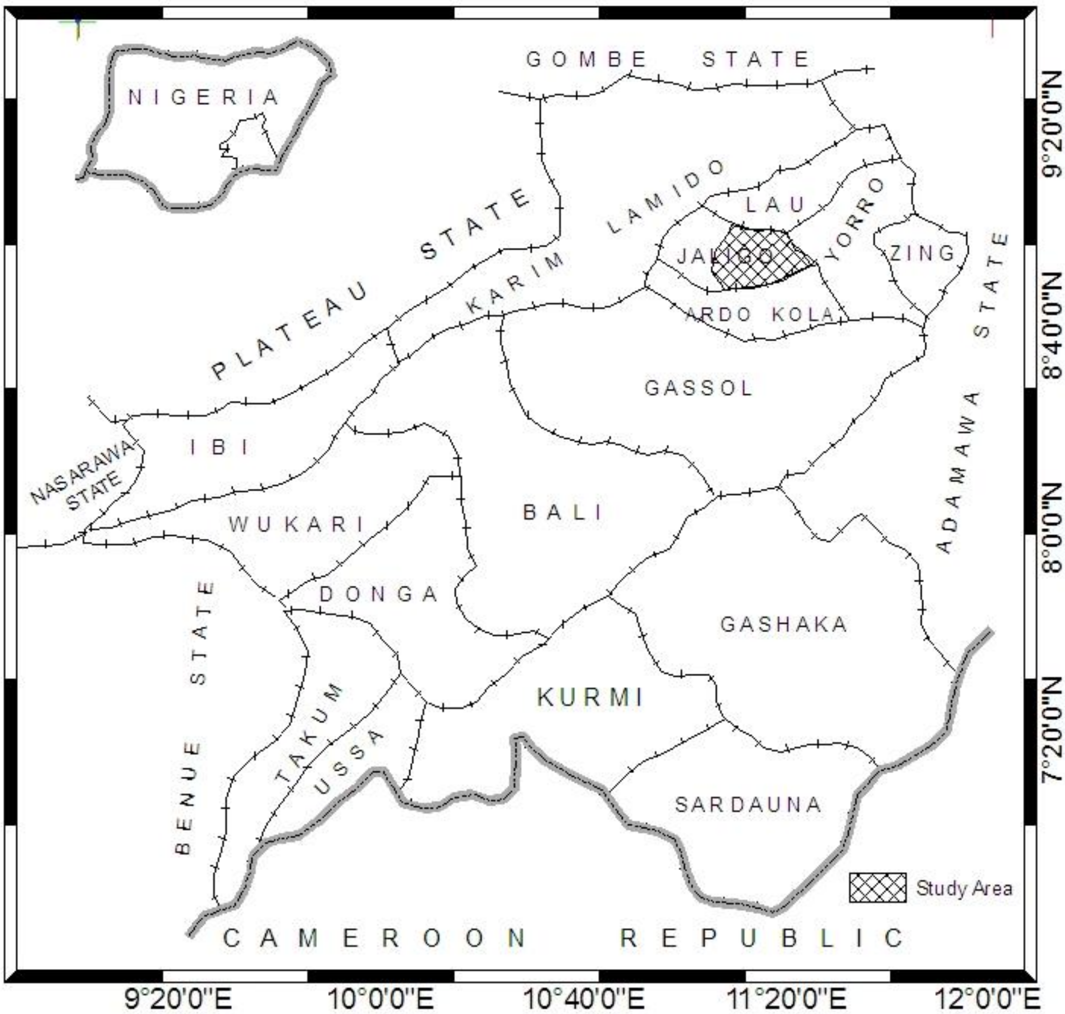

Fig 1: Map of Taraba State Showing the Study Area

The typical vegetation types around Jalingo consists of open savannah woodland with tall grasses varying in heights from 1.5 to 3 meters and trees with short and broad leaves. Recently, the intensive practice of arable farming in the area and, particularly increased in the demand for fuel wood and other uses has affected vegetation greatly. The immediate environments, which use to be bushes and forest areas, have been overtaken by urbanization. The demands for land have led to the disappearance of pockets of forest reserves that are hitherto abound around the city.

The population census in Nigeria, in 1963, put the total population of Jalingo at 18, 214 people. This figure has been growing sharply over time, especially after the creation of Taraba state with its headquarters in Jalingo. The population rose to 74, 108 persons in 1991 and increased further to 148, 318 in 2006 (increase of over 100% in 15 years). The population, as projected to 2011, stands at 173, 055 persons (Table 1)

Table 1: Pattern of Population Growth of Jalingo City

Year	1963	1973	1991	2006	2011
Population (thousands)	18, 214	28, 884	74, 108	148, 318	173, 055
Annual Rate of growth (%)	3.5	3.5	6.5	5.8	3.8

Source: National Population Commission, Jalingo. Figure for 2011 was projected from 2006

Materials and Methods

Mapping land cover is achieved through image classification while land cover change is made possible via change detection. Three Landsat images were used to study land cover situations of Jalingo over time in this research. Landsat data offer great opportunity for the study of land use - land cover and has been available since 1972. The images were acquired on 1973/12/03, 1991/11/14, and 2009/11/26 and corrected to level 1G before delivery in GeoCover dataset. The 1973 image was captured by Landsat-1 carrying a Multispectral Scanner Sensor (MSS) with 79m resolution and a path/row of 200/54 while the 1991 and 2009 were captured with Lnadsat-5 and landsat-7 with Thematic Mapper and Enhanced Thematic Mapper Plus sensors respectively and spatial resolutions of 30m at 186/54 path/row. In view of these disparities in the images, they were resampled using nearest neighbour algorithm to a spectral resolution of 80m for all the bands. Resampling the higher resolution to low resolution images degrades the quality of higher resolution image (Zemba, 2010). However, this was done because the quality of low resolution cannot be improved by resampling to higher resolution image yet it was necessary that each pixel in the lower resolution should have a corresponding pixel in the other images. The detail loss due to resampling the TM and ETM+ images to MSS was adequately compensated by the ability of data to make quick, logical comparisons between the images, since they now have the same path/row and resolutions.

Another image pre-processing task performed was the gap-filling of the 2009 Landsat ETM+ image with respect to the scan-line correction error effect using ERDAS Imagine version 9.1 software using a conditional function of *EITHER <arg1> IF (<test>) OR <arg2> OTHERWISE* algorithm. The images were then subjected to supervised classification using maximum likelihood algorithm to derive land use-land cover types. The accuracy of the classification was checked using reference data collected randomly from different land cover types identified from high resolution aerial photograph of the study area. Image differencing algorithm was employed to detect changes in LULC between the periods considered. Image differencing is probably the most widely applied change detection algorithm (Singh, 1989) and it involves subtracting one date of imagery from the second date that has been precisely registered to the first. Area of change was designated as 1 and area of no change as 0. A change matrix was produced as a result of image differencing and this was then used in assessing the values of change in each land cover type. In addition, the classified images were overlaid on each other so as to analyze the strength, rate and locations of changes in arable lands.

Results and Discussion

Patterns of Land use-land cover change (LULCC) dynamics

Results of image classifications as seen in Fig.2 reveal that arable land was a dominant feature around Jalingo in 1973.

This constituted about 83% (200, 771.2 hectares) of the total land cover in the area.

existing and potential farmland areas. The remaining 17% were land cover types that cannot be used for agricultural purposes. These include built-up areas, rocky outcrops, water bodies, and bare surfaces.

The arable land was drastically reduced to 155, 638.2 hectares (equivalence of 75% of the total land cover) in 1991 due largely to urban expansion. This means that about 45, 133 hectares (20%) of arable land was lost to other uses. A greater change occurred between 1991 and 2009 that left only about 29, 675 hectares (12%) of the total land area under cultivation. By 2009 about 88% of the total land area was non-arable (Table 1). These land areas were uncultivable because they are either under

Arable lands in this study imply all

uses such as built-up, water bodies and barren lands

The rate of conversion was very rapid between 1991 and 2009 because of the fact that Jalingo was made the state capital of Taraba state in 1991; hence there was massive influx of people into the city in order to occupy the newly created state government offices as well as Federal ministries and agencies. As the number of inhabitants increases, so is the demand for shelter and office spaces thereby leading to expansion in built-up areas. This happened at the expense of farmlands around the city. Consequently, the farmlands were pushed further away from the city core until they eventually disappeared at the foothills of Jalingo, Hosere, Jauro Ashe and Dambature hills that surround the city.

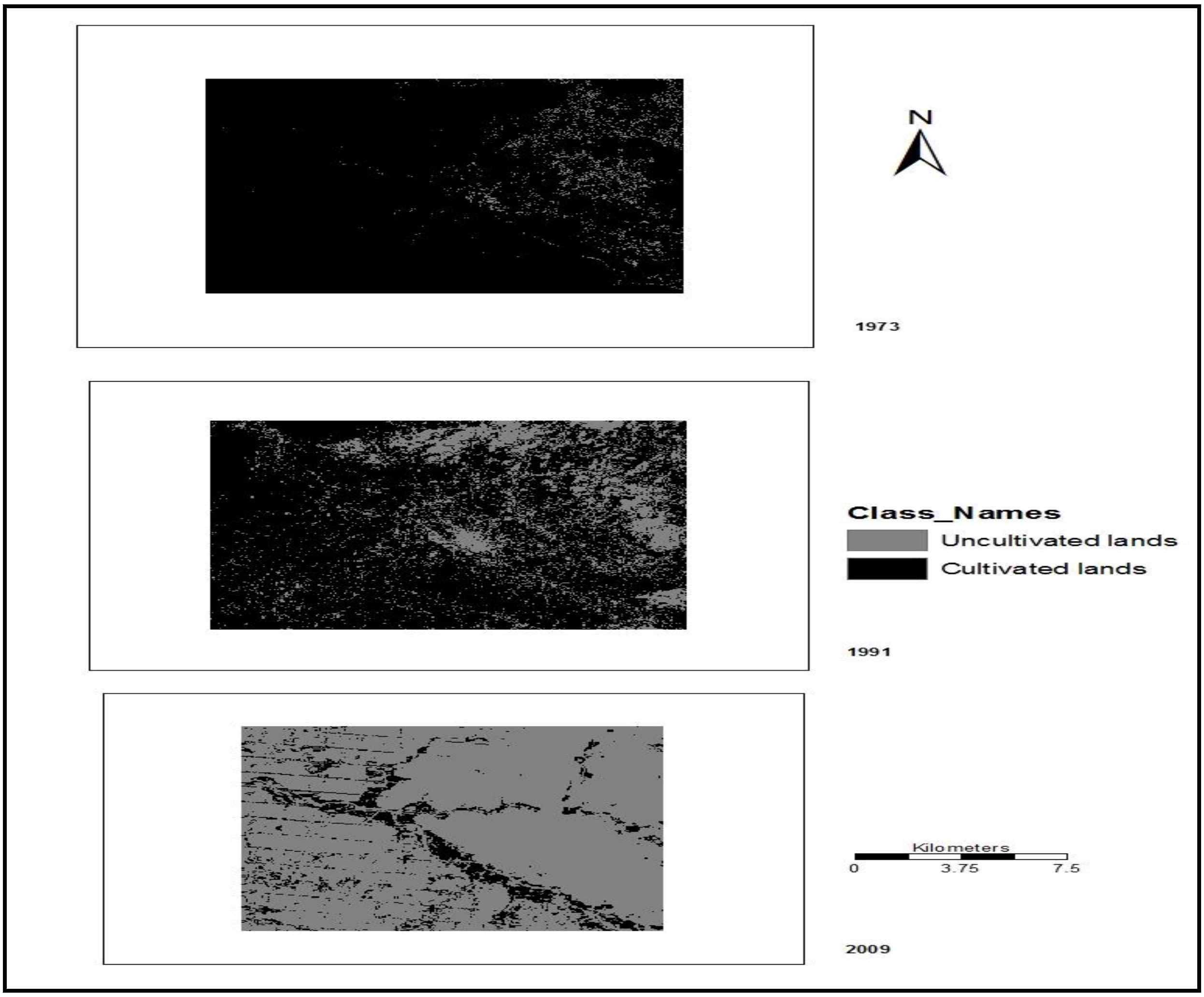

Fig 2: Areas of Cultivated and Uncultivated Lands in Jalingo

Table 2: Pattern of changes in arable and non-arable lands 1973-2009

	1973	%	1991	%	2009	%
Arable Lands	200, 771.2	83.2	155, 638.2	64.5	29, 675	12.3
Non- Arable Lands	41, 121.8	16.8	85, 730.8	35.5	211, 694	87.7

Changes in Arable land Areas

Further analysis of changes in arable lands of the study area was performed using image differencing and overlay in ArcGIS 9.3. This was to estimate land areas as well as their rate of conversions. This enabled us to determine quantitatively the values and rate of such changes in land uses overtime. The results in Table 2 show that arable land, which was 200, 771.2 hectares in 1973 suffered great encroachments by other land use types that led to its reduction to 155, 638.2 hectares (20%) in 1991. A more rapid transformation was recorded between 1991 and 2009, where it further declined to 29, 675 hectares (reduction by 81%). This represents a rate of change of about 7, 000 hectares between these periods. On the whole, about 85% of arable lands of about 200, 771.2 hectares in 1973 have been converted to other uses, leaving only 29, 675 hectares (12%) by 2009. This means that approximately 5, 423 hectares of arable lands are lost annually around Jalingo region.

Table 3: Land area and rate of decline of arable lands around Jalingo city

	1973	1991	2009
Arable land area (ha)	200, 771.2	155, 638.2	29, 675
Decline in Arable land during the interval (ha)	-	45, 133	125, 963.2
Percentage decline in arable land during the interval (%)	-	20.1%	80.9%
Decline in arable land compared with 1973 (ha)	-	45, 133	171, 096.2
Percentage decline in arable land compared with 1973 (%)	-	20.1%	85.2%

Implications of the loss of arable lands in Jalingo

The rate at which the transformation of arable lands is taking place in Jalingo is so phenomenal requiring urgent attention. The observed pattern of change points to much environmental, social and economic implications for the inhabitants of the area. For instance, the annual conversion rate of about 5, 423 hectares of arable lands to other uses, most especially, to urban or built-up areas within 36 years means that the whole natural vegetation in the area may be lost in about 30 years to come, if no direct and urgent intervention measure is taken. The implications of this on the ecological biodiversity and the livelihoods of those dependent on these resources will be enormous. Over 80% of the inhabitants of the area are made up of farmers and fuel wood vendors, whose livelihoods are directly dependent on agricultural activities and vegetation resources. This means the sources of livelihoods of these people are at stake.

The incidence also portends a great danger of the adverse effects of climate change due to rapid loss of vegetation cover. Overall assessments by Kainay and Cai (2003) have indicated that climate change is largely induced by human factors especially clearance of vegetation cover. The rate of vegetation destructions around Jalingo is a pointer to the fact that the local and regional climate is being modified, the consequence of which may have far reaching effects. Already scientists, in recent years, have recognized that land use-land cover change induced by human activities have large impacts on regional climate (Owen et al., 1998, Tran et al., 2001, and Zemba et al., 2010). Air pollution that is usually associated with urbanization do not only contributes to adverse climate change effects but poses serious health implications.

Natural vegetation provides protection against environmental hazards such as floods and erosions. Their depletion means placing the environment at risk. The perennial incidences of flooding in Jalingo area has been exacerbated in recent years. This is not unconnected to the increasing reduction in vegetation cover as observed in this research. The menace of erosion is common in the area as evident by the presence of deep gully sites within and around the city. This has resulted to destructions of houses and properties worth millions of naira in the area in recent years.

Economically, the loss of vegetation cover, coupled with the topography of the city results to increased erosion as stated earlier. This implies a reduction in the available lands for economic activities thereby reducing the means of livelihoods of the inhabitants.

It has been established that Jalingo city is surrounded by ranges of hills to the north and east.

By 2009, settlements have almost reached the foothills of these features. Farming activities in these parts of the city had ceased. Pressures on farmlands have now been directed to the only available lands in the south and west, thereby exposing these areas to further degradations. Another alternative is that some farmers are forced to abandon farming while those who must go on would have to travel over long distances outside Jalingo area to be able to acquire pieces of farmlands. The implication is that more moneys have to be spent by these farmers on transportations. On the other hand, because many people are no longer engaged in farming, they have to buy everything from the markets even at higher costs.

Conclusion

The land cover of Jalingo region has been subjected to tremendous transformations as a result of rapid urbanization and increased population growth. Thus, substantial quantities of arable lands, which provide sources of livelihood for over 80% of the inhabitants, have been converted to urban built-up lands. The rate of conversions is so enormously high (5, 423 hectares/annum) that the environmental sustainability tends to be highly jeopardized. The situation points to a danger of food insecurity, health implications, environmental hazards, and vulnerability to loss of properties and lives. Direct and urgent interventions need to be put in place by policy makers in order to arrest the unfortunate situation so as to avert or mitigate some of its impending consequences.

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