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Species Diversity, Land Use Changes and Ecosystem Services in selected communities in Kogi State, Nigeria

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Abstract

Anthropogenic activities have resulted in various land use practices and management regimes for conserving ecosystem and biodiversity particularly in a rapid developing urban centre. Geographic information system and remote sensing technologies have shown their great capabilities to solve the study issues like land use and land cover changes. This research investigated land use and vegetation cover of urban and peri-urban centres of Kogi State. Tree identification and growth variables measurements of diameter at breast height (Dbh) and total height were made on all trees with Dbh = 10 cm within the sample communities. The biodiversity indices computed were Shannon-Wiener diversity index, species evenness, and other biodiversity indices were employed to determine the tree species diversity of the communities. Administration of questionnaire for the survey of ecosystem services consisting of 200 household heads was adopted for this study. The results indicated that there were 1,151 stems in these communities which belong to 153 tropical tree species distributed into 27 families. The Shannon-Wiener diversity index of (2.83 to 3.24), species evenness (0.50 to 0.61) and other diversity indices were very high, indicating that urban forest has potential to conserve biodiversity. Geographical Information System (GIS) and Remote Sensing (RS) showed adequately the level of land use changes and vegetation cover within the communities selected for this research in Kogi State. This study provides the baseline information in relation to species diversity, ecosystem services and level of land use which has greater impact on the livelihood of the people within the society.

Keywords: Diversity indices, ecosystem services, Land use, Vegetation cover, Urban forest

Introduction

Land use serve as basis for the management of land resources for all levels of environmental planning with the careful use of classification criteria within the urban forest area. Land use and land cover changes especially those caused by human activities is the most important component of global environmental change with impacts possibly greater than the other global changes (Turner *et al*., 1994, Jensen, 2005). The rapid growth in population, infrastructural development, economic output and the consequent changes in land use pattern have implications on the natural environment (Cohen, 2004; Ifatimehin and Ufuah, 2006; Ifatimehin and Musa, 2008; Ifatimehin *et al*., 2009). The consequences on the environment include degradation, depreciation, depletion and deterioration of resources. These are the major environmental problems of the 21st century affecting the people and the environment leading to the reduction in life expectancy of human being.

Sackey (2008) and Huang *et al* (2003) reported that uncontrolled land expansion and its transformation lead to loss of natural vegetation and open space and a general decline in the extent, efficient and effective provision of ecosystem services to the environment undergoing such change. Additionally, land use is of critical importance for biodiversity conservation,

loss and sustainability of such resources within the environment. An urban forest is a forest or collection of trees that grow within a city, town or suburb (Losos and Leigh, 2004). Urban forests play important role in ecology of human habitats in many ways: they filter air, protect watersheds, protect from harsh sunlight, provide shelter to animals, protect ozone layer, and provide recreational areas and parks for people. They moderate local climate, reduce erosion, protect the soil, slowing wind and storm water, and shading homes and business areas to conserve energy.

There is abundant evidence that destructive land use practices, widespread pollution, exploitation of species, and perhaps global climate change have caused damage to the Earth's ecosystems and consigned many species to oblivion (Kessler, 2005). There is therefore a need to monitor such changes within the environment and to understand the processes, to be able to measure and plan adequately in order to improve tree direct growth for healthy development of the people within the urban areas.

METHODOLOGY

Study Area

This study was carried out in four different communities (Kabba, Okebukun, Okoro-Gbede and Iyara) within Kogi State, Nigeria. Kogi State lies between latitudes 7°49'N and 7°30'N and longitude 6°42'E and 6°45'E. The State has Lokoja as the administrative headquarters and it is well connected and accessible through State and Federal highways. The climate is characterized by wet and dry season. The geology of study site is dominated by crystalline rocks of the basement complex which provide mostly granitic materials. At the valley bottoms are wetland soils formed as a result of deposition of minerals (Babalola *et al.*, 2011).

Kabba and the surrounding communities to the North, South, East and West were surveyed, and data on species diversity and socio-economic variables were collected. The selection of study areas was done purposefully based on the proximity to the Kogi State capital.

Data Collection

Ecosystem Services of Urban Forest

Semi-structured questionnaire was used to obtain information from respondents on socio-economic and environmental impacts (ecosystem services) of urban forest. Fifty respondents were purposively selected from each community. Thus, a total two hundred (200) questionnaires were administered for the study. The questionnaires were administered inform of interview to sort information on the ecosystem services of urban forests to the populace. All questionnaires administered to respondents were retrieved for analysis.

Sampling of Tree Biodiversity

Field work was also carried out in the selected communities (Kabba, Iyara, Oke-Bukun and Okoro-Gbede). Areas such as schools, higher institutions, churches, public and private institutions ground with high level of tree population were explored. Also green areas such as avenue, street, gardens, amusement parks, religious centres, home gardens were visited for detailed enumeration. Tree species were identified and their coordinates taken with hand-held Global Positioning System (GPS). All trees with diameter at breast height (Dbh) greater than or equal to 10 cm were identified, height was measured with Spiegel Relaskop, diameter at breast height (Dbh), diameter at the base (D_b), diameter at the middle (D_m) and diameter at the top (D_t) were measured with Girth Tape and their frequency taken. Tree identification was done using keys in flora manuals and match-up technique.

Analysis of Tree Species Diversity

All tree species within the selected communities in Kogi State were assigned to families using Keay (1989) as guide. To facilitate comparisons with other tropical forests, trees with dbh = 10 cm were enumerated and basal area, volume, relative density, relative frequency, relative dominance and importance value indices (IVI) were estimated following Curtis and Cottam (1962). In addition, relative density and relative dominance were calculated according to the formulae of Mori *et al*. (1983). Shannon-Wiener index and Pielou's measure of evenness were calculated following Magurran (1988) and Sorenson's coefficient of similarity (Magurran 1988, Small *et al*., 2004).

Species Relative Density (RD):

$$RD = \left\{\frac{ni}{N}\right\} x\ 100$$

Where: RD (%) = species relative density; n_i = number of individuals of species i; N = total number of all individual trees of all species in the entire community.

Species Relative Dominance (RDo):

$$RD_O = \frac{(\sum Ba_i\ x\ 100)}{\sum Ba_n}$$

Where: Ba_i = basal area of all trees belonging to a particular species *i*; Ba_n = basal area of all individual tree.

Importance Value Index (IVI):

$$IVI = \frac{(RD + RD_o)}{2}$$

The importance value index (IVI) for trees was calculated from the values of relative density RD (%) and relative dominance for trees RDo (%) divided by 2.

Species diversity index

$$H' = -\sum_{i=1}^{s}{}' P_i \ln(P_i)$$

Where: H' = Shannon-Wiener diversity index; S = total number of species in the community;

p_i = proportion of S made up of the ith species; ln = natural logarithm.

Shannon's maximum diversity index

$$H_{max} = \ln(S)$$

Where: H_{max} = Shannon's maximum diversity index; S= total number of species in the community.

Species evenness

$$E_H = \frac{H'}{H_{max}} = \frac{-\sum_{i=1}^{s} P_i \ln(P_i)}{\ln(S)}$$

RESULTS

Tree Species Distribution in Selected Communities

One hundred and fifty-three (153) tree species, distributed among twenty-eight (28) families were identified in the selected communities. Sixty-two (62) tree species belonging to 25 families were identified and enumerated in Kabba; Thirty-one (31) tree species from 16 families were enumerated in Oke-Bukun; Twenty-six (26) tree species from 14 families were found in Iyara while thirty-four (34) tree species from 19 families were identified in Okoro-Gbede (Table 1). Families with the highest number of tree species include: Mimosoideae, Moraceae, Apocynaceae, Euphorbiaceae, Combretaceae, Verbanaceae, Papilionoideae, and Anacardiaceae.

Biodiversity Indices and Growth Variables of the study areas

The biodiversity indices and growth variables of the tree species within the selected locations is shown in Table 1. Species Relative Density (RD) ranges from 0.15 – 11.89%, 0.65 – 12.9%, 0.5 – 18.09%,

and 0.71 – 16.31% in Kabba, Oke-Bukun, Iyara and Okoro-Gbede communities respectively. Species with high relative density include: *Mangifera indica* (11.89%), *Gmelina arborea* (8.54%) and *Anacardium occidentalis* (7.93%) in Kabba; *Newbouldia laevis*(12.9%), *Gmelina arborea* (10.32%) and *Citrus sinensis* (8.39%) in Oke-Bukun; *Gmelina arborea* (18.09%), *Mangifera indica* (11.06%) and *Newbouldia laevis*(8.54%) in Iyara while Okoro-Gbede had *Citrus sinensis* (12.77%), *Mangifera indica* (16.31%), *Gmelina arborea* and *Parkia biglobosa* (7.09%) with the highest density.Species Relative Dominance (RD_o) varies from 0.07 – 18.79% in Kabba, 0.19 – 24.77% in Oke-Bukun, 0.50 – 18.09% in Iyara, and 1.16 – 6.47% in Okoro-Gbede community.Species with high Relative Dominance were: *Delonix regia, Mangifera indica* and *Parkia biglobosa* with 18.79%, 6.44% and 5.14% dominance respectively in Kabba; *Adansonia digitata, Mangifera indica* and *Spondias mombin* with 24.77%, 5.65% and 5.35% dominance respectively in Oke-Bukun; *Gmelina arborea, Mangifera indica* and *Newbouldia laevis*with 18.09%, 11.06% and 8.54% dominance respectively in Iyara while in Okoro-Gbede community, *Parkia biglobosa, Delonix regia* and *Dacryodes edulis* had the highest relative dominance of 6.47%, 6.44% and 5.76% respectively. The Importance Value Index (IVI) generated for the tree species varies with each tree species in each location: *Delonix regia* (9.47), *Mangifera indica* (9.16), *Gmelina arborea* (5.23) in Kabba; *Adansonia digitata* (14.64), *Gmelina arborea* (7.66) *Newbouldia laevis*(6.82) in Oke-Bukun; *Gmelina arborea* (12.38), *Mangifera indica* (7.98), *Parkia biglobosa* (6.82) in Iyara and *Mangifera indica* (10.71), *Citrus sinensis* (7.12), *Parkia biglobosa* (6.78) in Okoro-Gbede were the most important species. The results of Shannon-Wiener diversity index (H') for the four communities are: 3.24 (Kabba), 3.08 (Oke-Bukun), 2.83 (Iyara) and 3.04 (Okoro-Gbede) while the values of Shannon's maximum diversity index are 6.49 (Kabba), 5.04 (Oke-Bukun), 5.29 (Iyara) and 4.95 (Okoro-Gbede). The results of tree species evenness (Shannon's equitability index, E_H) computed for the communities are 0.50 (Kabba), 0.61 (Oke-Bukun), 0.54 (Iyara) and 0.61 (Okoro-Gbede). The Mean Dbh (cm) of the tree species were 40.50 (Kabba), 51.53 (Oke-Bukun), 46.67 (Iyara) and 40.16 (Okoro-Gbede). The total mean volumes (m^3) of the tree species were: 101.2 (Kabba), 102.1 (Oke-Bukun), 101.7 (Iyara) and 101.2 (Okoro-Gbede) while the Basal area (m^2) values were: 61.0 (Kabba), 58.1 (Oke-Bukun), 54.8 (Iyara) and 54.6 (Okoro-Gbede).

Table 1: Tree species diversity and growth variables

Biodiversity Indices	Kabba	Iyara	Oke-Bukun	Okoro-Gbede
No of Family	25	14	16	19
No. of Tree Species	62	26	31	34
Mean Dbh (cm)	40.50	46.67	51.53	40.16
Basal Area (m^2)	61.0	54.8	58.1	54.6
Maximum Dbh (cm)	162.0	78.5	160.1	61.5
Volume (m^3)	101.2	101.7	102.1	101.2
Diversity Index (H')	3.24	2.83	3.08	3.04
Species Evenness (E_H)	0.50	0.54	0.61	0.61

Land Use Classification of the Selected Communities

Table 2 results indicated the extent of land use of the study areas between 2001 and 2015 as shown in Figures 1 and 2. The built-up area in Kabba, formerly occupied by 36.32% in year 2001 (Figure 1) increased to 48.24% in year 2015. In Iyara community however, the built-up area increased from 12.84% in 2001 to 17.40% in 2015. Oke-Bukun community also experienced an increase in the built-up area from 12.54% in 2001 to 13.50% in 2015 while the built-up area in Okoro-Gbede decreased tremendously from 18.80% to 22.40%. In 2001, Kabba consists 30.10% of light vegetation which reduced drastically to 23.92% in year 2015; Iyara also consists 26.14% of light vegetation which reduced to 28.14% in 2015; the light vegetation in Oke-Bukun decreased slightly from 30.92% in 2001 to 35.20% in 2015. However, light vegetation expands in Okoro-Gbede from 20.09% to 20.98% in 2015. Dense vegetation reduced throughout the regions between the years of interest; 12.16% to 8.12% (Kabba), 20.76% to 16.24% (Iyara), 36.12% to 30.16% (Oke-Bukun) and 28.20% to 26.10% (Okoro-Gbede). The percentage of Rocky areas reduced due to the level of construction in the area from 17.32% to 11.59% in Kabba, 29.68% to 25.52% in Iyara, 10.14% to 10.04% in Oke-Bukun and 22.60% to 20.38% in Okoro-Gbede community. There are more area of land opened up due to the anthropogenic activities which expand the bare surfaces from 4.10% to 8.13% in Kabba community; 10.58% to 12.70% in Iyara community; increased slightly from 10.28% to 11.10% in Oke-Bukun and decreased significantly from 10.31% to 10.14% in Okoro-Gbede community.

Table 2: Extent of Land Use from 2001 - 2015 in four (4) Communities

Land Use Classification	Kabba		Iyara		Oke-Bukun		Okoro-Gbede	
	2001	2015	2001	2015	2001	2015	2001	2015
Built-up area (%)	36.32	48.24	12.84	17.40	12.54	13.50	18.80	22.40
Light Vegetation (%)	30.10	23.92	26.14	28.14	30.92	35.20	20.09	20.98
Dense Vegetation (%)	12.16	8.12	20.76	16.24	36.12	30.16	28.20	26.10
Rock (%)	17.32	11.59	29.68	25.52	10.14	10.04	22.60	20.38
Bare Surface (%)	4.10	8.13	10.58	12.70	10.28	11.10	10.31	10.14

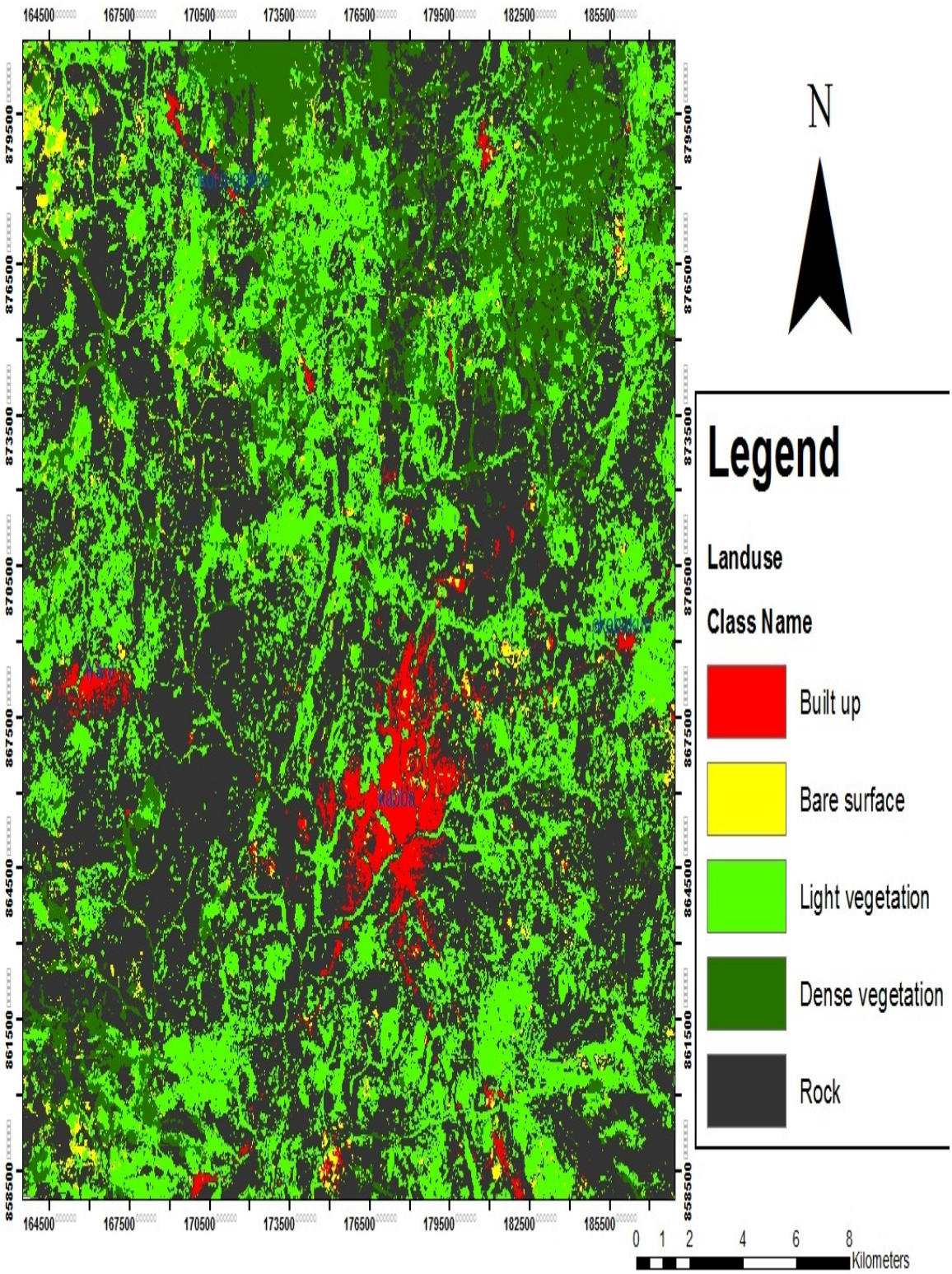

Figure 1: Land use map of the study areas 2001 (Landsat 5 TM Imagery)

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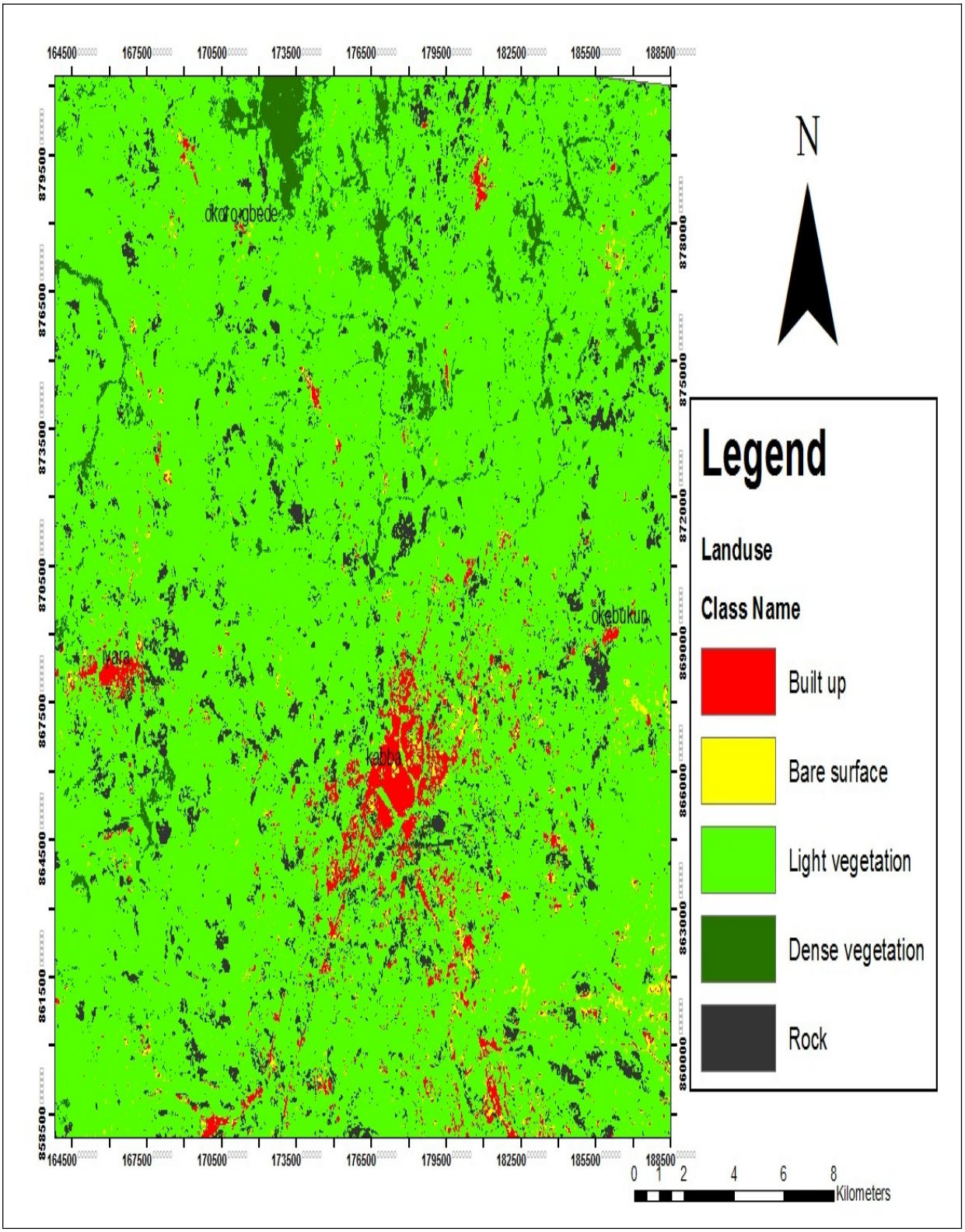

Figure 2: Land Use Map of the Study Areas 2015 (Landsat 5 TM Imagery)

Table 3 shows the result on benefit derived from urban forest in the study communities. The result shows that 85 out of the 100 respondents in Kabba opined that trees provide then with edible fruit and shade for social gathering in urban settlement while 80 respondents each said that they utilize urban forest for relaxation/garden and religion centers. Also the result shows that 70 and 65 out of the 100 respondents in Iyara said urban forest provide them with edible fruits and beautification respectively, while 60 respondents each equally said urban forest is used for wind break and religion center. The result also show that 85 and 80 out of 100 respondents in urban settlements in Oke-Bukun said urban forest is used for religion center and relaxation/garden respectively, while 75 and 70 respondents said they derived beautification and fuel wood respectively from urban forest. Also the result shows that 80 and 75 out of the 100 respondents in Okoro-Gbede said urban forest provide them with fuel wood and religion center respectively, while 60 respondents each equally said urban forest is used for wind break and provision of fruit.

Table 3: Benefits of Urban forests in Ekiti State

	Kabba	Iyara	Oke-Bukun	Okoro-Gbede
Edible Fruits (Food)	85	70	60	60
Beautification	55	65	75	50
Medicinal (Herbs)	60	40	55	40
Event Centre	40	40	20	55
Vegetable (Soup)	50	55	65	50
Shade (Social Meeting)	85	50	65	40
Fuelwood (Cooking)	45	40	70	80
Relaxation/Garden	80	50	80	30
Wind break	40	60	55	60
Religion Centre	80	60	85	75

DISCUSSION

Tree Species Distribution within the Selected Locations

This research indicated that tree planting around houses in Nigeria was largely based on their nutritional, economic, social, cultural, religious and other purposes. Biodiversity indices of urban and peri-urban are generated in order to appreciate the level of diversity and abundance of species in certain location within the country which can be compared with similar forest reserve areas. IIRS (2011) noted that biodiversity indices are generated to bring the diversity and abundance of species in different habitats to similar scale for comparison and the higher the value, the greater the species richness.This, in a way, has contributed to food supply and nutritional supplement in diets of urban dwellers in Nigeria. The result of this study revealed that urban green can have positive impact on the life of the people living in these areas by providing urban forest benefits which include, reducing air pollution, reducing stress, providing fuel wood for cooking, tree species diversity and ecological roles as observed by O' Brien *et al.,* (2010). This study also agrees with Kuchelmeister and Braatz (1993) in their report that trees contribute significantly to the aesthetic appeal of the cities, thereby maintaining the psychological health of city inhabitants. The diversity of forest cover type, land-uses, population densities, and land ownerships across many urban areas calls for complex, long-term urban forest management plans as reported by Dwyer *et al*., (2000).

Land Use Classification of the selected communities

Land use and land cover classes produced from the supervised classification process which was wielded in this study. Five (5) classes were generated; which are Built-up Area, Light Vegetation, Dense Vegetation, Rock and Bare surface. The built-up area includes all residential, commercial and industrial development such as transportation routes and many more. The light vegetated area reveals all vegetation features that are not typical of forest, including agricultural and pasture grasslands, recreational grasses, and shrub like vegetation features. The dense vegetation includes all forest vegetation types including evergreen, deciduous, and wetland forest vegetation types, the woody areas, grasslands and forests still in a healthy condition. The bare surfaces are most often represented by water bodies and bare earth or soils which are heavily degraded (marginal land). This is mostly because of the fact that there are such geological features as the Great Dyke, rocky outcrops and severely degraded lands due to intense agriculture and constructions.

Classification and post-classification overlay was carried out and thematic land-cover maps for the year 2001 and 2015 were produced for the study areas by supervised classifications using a maximum likelihood classifier. This was used to map the patterns and extents of land use and land cover in the study area as well as determine the magnitude of changes between the years of interest, 2001 and 2015. The changes in land use over the years show an accelerated growth rate of urbanization in these areas. Light vegetation showed the greatest amounts of decrease in the study areas with dense vegetation increasing slightly more; other significant changes occurred within the rock class (Konijnendijk et al., 2004). The classification procedure used was able to distinguish five land uses classes; overall changes in the landscape show an increased trend for urban development with the vegetation and bare surfaces suffering the consequences (Adam *et al.*, 2002).

Ecosystem Services Derived from Urban Forests

Urban tree species encountered in the selected communities are used for foods and shades (edible fruits/seeds, vegetables), nutrition supplement, medicinal substances and fuel wood. Onyekwelu and Olaniyi (2012) had observed that urban forestry practices improve food security and nutrition of poor urban inhabitants through collection of wild edible plants as vegetable and fruits. There are environmental and ecosystem benefits derived from urban forest such as provision of shade for cooler air, beautification and aesthetic purposes, relaxation parks and gardens for entertainments, social and religious meetings as it was opined by (Agbelade *et al.*, 2017).

CONCLUSION AND RECOMMENDATION

This study provides information on land use change and ecological vegetation distribution within selected communities in Kogi State. It shows the current level of development in the selected areas and tree species diversity which enhanced the beautification of the communities. It also revealed the diversity of tree species within the urban settlements and the nature of the tree species, as well as their contribution to biodiversity conservation. The identification of the tree species has also improved the knowledge acquired about forest trees and their importance; this is a vital factor in the development of green areas. Therefore, this research recommend that people should be advised against deforestation and logging activities, rather they should be encouraged to plant more trees by informing them on the ecological benefits. This study also recommends that laws and regulations guiding against indiscriminate destruction of forests be provided and enforced in every parts of Nigeria. In order to facilitate more awareness and consciousness of our environment, this study also suggests that Conservation education be taught in schools and conservation clubs should be introduced to students in secondary schools and higher institutions.

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