Urbanization and its effects on land and water resources in Ijebuland, southwestern Nigeria

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Abstract

The many widely reported significant environmental changes in sub-Saharan communities caused by population change and expansion of built-up areas have seldom been documented in detail. Poor documentation of environmental changes and their effects may contribute to poor governance and planning in parts of the region. This study examined change in the form and attributes of areas under different land cover in a relatively homogenous Yoruba ethnic group community in Southwestern Nigeria. It used a mix-method approach of remote sensing and social surveys analysis. Landsat images covering the area for 1986, 2000 and 2016 were evaluated for land use/cover change, and the impact of the changes was assessed with social surveys (questionnaire administration and key informant interviews). Results showed a 212.2% increase in the built-up area and a corresponding decrease in forest and surface water area (streams) by 74.4% and 66.3%, respectively. Coping strategies were weak and overtly reactive, as there appeared to be no evidence of any previous plan for response to such degrading effects. The study concluded that urbanization exhibits degrading effects on land and water attributes in the area, and therefore recommends improved monitoring of the region through relevant policy and institutional investitures.

Keywords Urban growth · Water resources · Vegetation · Landsat image

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1 Introduction

Urbanization is a process of town development that may be a source of problem, requiring solution or influenced to bring about development in an area (International Union of Local Authorities, 1967). It is a process of building development; a social and a physical process changing both land and people's lives (Awomeso et al., 2012; Ekpenyong, 2015; Mohammad, 2016). In many developing regions, including Asia and Africa, urbanization is characterized by rapid growth in urban populations, occasioned by rural–urban migration and natural increase by births (UNFPA, 2017). The processes leading to urban growth are usually accompanied by several unintended consequences on land use, livelihoods, land cover and distribution (and abundance) of water resources and general ecosystem diversity.

Studies in Nigeria and other parts of the world (Bloch et al., 2015; Jiboye, 2011; Olorunfemi, 2014) have argued that urbanization often leads to urban expansion. This is because fallow lands that were hitherto forest resources and agricultural land are encroached upon and transformed into built-up areas to accommodate new urban population. Also, urbanization has been associated with habitat destruction, deforestation, degradation, biodiversity loss, flooding and urban heat in many countries, in Europe, Asia and Africa (Chagutah, 2009; Ramachandra et al., 2019; Wani & Khairkar, 2011). The effects of urbanization processes also include loss of drainage basin to infrastructural development; and in many coastal environments, water bodies have been sand filled to build 'palatial' edifices and 'state-of-the-art' communities (Guan et al., 2018; Idu, 2015; Karthiyayini & Sundaram, 2016). In general, the United Nations (2008) and UNFPA (2017) stated that more than 90% of future population growth will be concentrated in cities in developing countries, and a large percentage of this population will be poor, and unable to cope with the stresses that are associated with the impact of urbanization on resources and climate change. Existing urbanization theories recognize the importance of a spread effect or trickle-down effects (a process of socio-economic growth of areas around the urban centers) and a backwash effect (processes explaining decline in growth of rural areas around urban areas, in socio-economic terms) (Okafor, 2004). On the loss of agricultural land to urbanization, Bozhinova (2018) noted that 31 million acres of farmland (translating to $992 billion) were lost to urban growth in the USA between 1992 and 2012. In Nigeria, studies (including FAO, 2017; Matemilola, 2017; Muhammed et al., 2015; Njungbwen & Njungbwen, 2011) have linked recent challenges in agricultural production in many parts of the country to loss of agricultural land to urbanization and poor mechanization of agriculture activities, among others. Information on how urbanization affects agricultural productivity is therefore essential for futuristic modeling of policy decision support programmes and their effects on human sustenance (FAO, 2017; Inam et al., 2012; Kim, 2009; Kristiansen, 2003). Whereas information available on Nigerian environment is at best, unorganized, and oftentimes available on small-to-medium-settlement-scale, regional-based studies are largely lacking, and thus regional resilience to agricultural changes that are influenced by urban growth are relatively (compared with studies from tropical region) scanty.

2 Research problem

Existing studies project an expansion in the range 1.2–1.8 million km^2 of urban areas, globally, due to urban population growth and economic development by between 2000 and 2030 (Seto et al., 2012; Balogun, 2020). The rate of expansion and extent of urban growth have been linked with multifaceted impacts on the global environment, including habitat destruction, food insecurity and loss of protected habitats, however, the scientific literature on direct impacts of urban growth on the environment is geographically biased, being concentrated on northeastern USA, Europe, coastal China, and Australia (McDonald et al., 2020). Countries in West Africa and Central Asia are least studied. The low quantity of publications on the direct effects of urban growth may reduce the capacity to model future impacts of urban growth on biodiversity and efficient frameworks for sustainable environmental management in the region (Eludoyin & Iyanda, 2019; Güneralp et al., 2013).

In addition, whereas some existing studies (such as Agbola & Adegoke, 2011; UNDESA, 2014) ranked Nigeria as one of the countries with high records of urban growth and population increase, knowledge about the direct impact of such attributes (increased urban growth and population) is rarely documented. Few of the existing studies on Nigeria (e.g., Eludoyin & Iyanda, 2019; Salami and Akinyede, 2006; Omodanisi et al., 2014) attribute the relatively poor information on the impact of urban growth in Nigeria to poor knowledge of essential technology with capability to capture relatively long-term data and high cost of high-resolution satellite images and associated processing technology. Consequently, given the available freely available Landsat images and subsided ArcGIS software and recently open source QGIS, efforts, such as the present study, are more able to provide information on the impact of urban growth and urbanization on the environment. Whereas the proponents of the Remote Sensing and Geo-information technologies in environmental studies have increasingly demonstrated their importance, evidence from existing studies reveals the capacity for better information when the technologies are used complementarily in conjunction with other field-based methods (Omodanisi et al., 2014; Omodanisi et al., 2015). In this study, the remote sensing and geographical information technology was adopted alongside with social surveys to examine the impact of urbanization in Ijebuland, southwestern Nigeria. The results from this study are expected to model other sub-regions in West Africa, as many studies have similar pattern of urban growth and population increase in the humid part of West Africa (Ganiyu et al., 2019; Lasisi et al., 2017).

Ijebuland first grew as an important regional agricultural hub in Nigeria in the colonial period (Aderinto, 2013; Agiri, 1977), and was thus an economic power for southwestern Nigeria until 1976 (Adebowale & Odesanya, 2015; Taiwo et al., 2017). Obayelu et al. (2019), among others, argued that four decades (from 1980s) of growth of towns and population increase in Ijebuland have resulted into loss of farmland and water resources but have failed to appropriately quantify the losses. Also, existing studies (Adeofun et al., 2015; Awoniran et al., 2014) have been speculative about the environmental losses, and available information is too generalized. Thus, this study uses information from social surveys to explain the temporal changes observed in the Landsat data.

3 Objectives and conceptual framework

The overall goal of this study is to contribute to attempts to bridge the existing knowledge-gap in the discussion of direct impact of urbanization on the West African environment that was observed in the literature (e.g., McDonald et al., 2011). The specific objective is to analyze the effects of urbanization on land conversion, and water resources in Ijebu region in Nigeria, from remotely sensed data and perception study. The conceptual framework adopted was informed by the quest for urbanization and the increasing influence of rapid and unmonitored urbanization on the environment. Williams et al. (2009)'s conceptual framework predicting the effects of urban environment and that of Li et al. (2016) on the impact of ecosystem services that assume that impacts of urbanization exhibit spatially heterogeneous attributes that are controlled by urban expansion and population mobility are the underpinning concepts for the study. The main assumption of this study is that sub-Saharan African countries and other developing countries, will be sufficiently ambitious to confront the challenges of meeting the targets of the Sustainable Development Goal (SDG), especially Goal 11, which is focused on 'making cities and human settlements inclusive, safe, resilient and sustainable' (Woodbridge, 2015). The goal seeks to 'support positive economic, social and environmental impact links between urban, peri-urban and rural areas by strengthening national and regional development planning, among other targets (Woodbridge, 2015). This study provides basis for information generation for ensuring well-informed policy decision in the study area.

4 Study area

The study area, Ijebuland, is a region within Ogun State in the southwestern Nigeria. The area is made up of communities under Sagamu, Odogbolu, Ijebu North, Ijebu North East, Ijebu Ode, and Ijebu East LGAs (National Population Commission, 2006). Ijebuland covers an approximate land area of 4496.76 km^2, within the tropical rainforest (Fig. 1). The region has become increasingly cosmopolitan as a result of its closeness to Abeokuta, the state's administrative capital since 1976. In terms of the relief, the region is characterized by a gentle undulating plain, below 100 m above sea level. The soils in Ijebuland are dominantly of the Ferralitic soil group (Adebowale & Odesanya, 2015) that are generally formed in the humid tropics due to chemical weathering and the accumulation of humus (Forbes et al., 1976). The soils are generally rich in ferro-manganese concentration, and are also characterized by deep with distinct profiles, high natural fertility and water retention capacity during the dry season; all of which make the soil attractive for farming activities (Ogunnowo, 2004).

The study area is within the tropical seasonally wet climate region of Nigeria, whose mean temperature ranges between 26.8 and 27.3 °C, and relative humidity of about 82.6–85.1% (Eludoyin et al., 2014). It is within the tropical rain forest vegetation zone of Nigeria, and characterized by evergreen forests that dominate the region; many parts of which have been degraded by anthropogenic activities, including farming and cutting timbers for construction (Mabogunje & Keats, 2004). Due to migration, civilization and inter-tribal marriage, Ijebuland is composed of a mixed people who mainly speak the general Yoruba language, and has an estimated (from the National Population Commission record of 997,344 in 2006) population of 1,249,214.
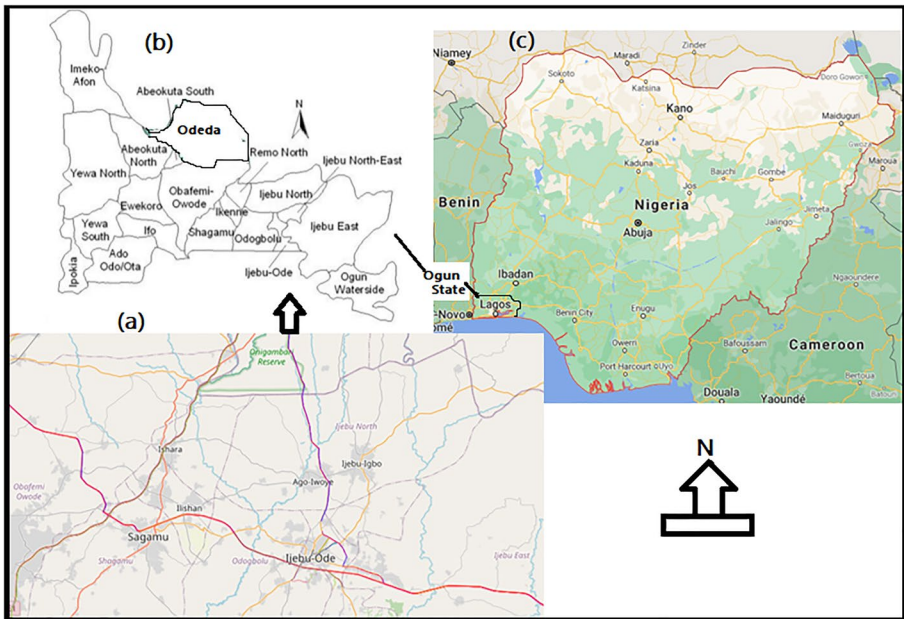
Fig. 1 The study area, Ijebuland (**a**) in southwestern part (**b**), Nigeria (**c**)

5 Materials and methods

5.1 Landuse/cover change analysis

Landsat images of 1986, 2000 and 2016, downloaded from the archive of the Global Image Visualizer (GLOVIS), were used for the study. The images were processed and analyzed in ENVI (version 5.3), while the output was presented in ArcGIS (version 10.3), based on the preferred cartographical advantage of the latter. The acquired Landsat TM images were of separate bands which were later stacked in the ArcGIS 10.3 to achieve a composite band. The process of mosaicking of the images was also carried out for each year since they were obtained from two paths and rows of 191/055 and 190/055. This stacking was done to allow for overlaying of the images in ENVI (version 5.3) environment. Geometric corrections such as georeferencing and rectifying the images to local datum were carried out using appropriate remote sensing procedure (Bastiaanssen et al., 2000; Patino & Duque, 2013; Rogan & Chen, 2004).

Consideration was given to the availability, accuracy and compliance of the datasets. Information derived from the topographic map and coordinates of physical benchmarks and other obvious structures in the area was used for georeferencing of the images as described in studies on GIS (Alexakis et al., 2014; Mallupattu et al., 2013). Although the Landsat images were in georeferenced format, studies (e.g., Ejaro & Abdullahi, 2013; Olorunfemi, 1983; Oloukoi et al., 2014) have indicated that localized georeferencing is required for enhanced accuracy.

Two processing operations, which are supervised classification and Normalized Differential Vegetation Index (NDVI), were performed for the Landsat TM data that were pre-processed. As theoretically described in Campbell (2002), supervised classification

requires that the image processing software is guided by the user to specify the land cover classes of interest. The supervised classification was performed on the pre-processed Landsat TM 5 for 1986 and 2006, while Landsat OLI/TIRS for 2016. Bands 4, 3, 1 were overlaid for classifying the 1986 and 2006 images, and bands 5, 4, 3 for 2016s. The supervised classification was achieved by training some selected pixels (training sites) for each of the specific dates as described in studies (such as Herold et al., 2005; Lu & Weng, 2007; Melesse et al., 2007). From these trainings were signature files generated in the forms of Regions of Interest (ROIs) in ENVI 5.3 and used for the classification process. The outputs of the process were thematic maps.

The NDVI was also analyzed to identify the changes that have occurred in vegetation cover over the study period. The NDVI is a measure of the density of the green vegetation, and it is often used in monitoring photosynthetic activity in order to detect vegetation fluctuations. The NDVI values range from -0.1 to $+0.1$ (Bhandari & Kumar, 2012; Gandhi et al., 2015; Weier & Herring, 2000). According to Weier and Herring (2000), the NDVI values that are very low (≤ 0.1) corresponds to barren areas of rock, sand and snow; moderate values of NDVI (0.2–0.4) correspond to shrubs and grasslands; and high NDVI values (> 0.4) correspond to temperate and tropical forests. Here, the NDVI was computed using the ratio between near infrared (NIR) and red light within the electromagnetic spectrum, such that the reflectance value in the red and near infrared bands were used as described by Gandhi et al. (2015).

5.2 Accuracy assessment of the imagery data

Accuracy of the classification method was assessed using a confusion matrix as described in the literature (Kafi et al., 2014; Kohavi & Provost, 1998; Lu & Zhou, 2004; Rwanga & Ndambuki, 2017). Each image was subsequently classified into different land uses and land cover (see Weng, 2012; Zhang et al., 2018, for the procedure). One-time accuracy assessment was conducted on the Landsat images used for land use/land cover classification for the study periods. This was done using the high-resolution Google Earth image for the recent years as reference data. Training sites randomly selected on the base maps during the post processing stage were 4528, 11,763 and 9662 sites for 1986, 2000 and 2016, respectively. Five categories of land classes were identified [using Anderson et al. (1976)'s classification procedure], and selected categories were 'built-up areas', thick forest', 'water bodies', 'farmland' and 'bare surfaces'.

5.3 Social surveys

Two communities were randomly selected in each of the six local government areas (LGAs) in the study area for the social surveys: questionnaire administration and key informant interview. 720 copies of a set of questionnaire were administered to household heads in the region, following the Cochran's (1977) standard formula for sample size determination at 0.05% for each LGA. Selected communities are Ogbere, Itele (Ijebu East LGA), Sabo, Soyindo (Sagamu LGA), Okun-Owa, Aiyepe (Odogbolu LGA), Oke-Sopin, Mamu (Ijebu North LGA), Idomowo, Obalende (Ijebu Ode LGA), Atan, Iworo (Ijebu North East LGA). The questionnaire was given to the literate participants (head of selected households) to complete, while the information was read

and interpreted to the non-literate before the necessary options were ticked (accepted) by the researchers and trained assistants. In cases where the head of household was unavailable, an adult (aged at least 18 years) member of the household was sampled. Information obtained from the respondents includes perception on causes and effects of urbanization in the area, and their experience of the change in urban growth and its implications on the environment. For the conduct of the key informant interviews, a purposively selected community leader from each of the entire (12) selected communities in the area, as well as one principal officer, each at of the Ogun State Agricultural Development Agency (OSADA)'s offices in Abeokuta and Ijebu-Ode were selected for interview. Selected questions also focused on perceived and documented (if any) causes, effects of urbanization, as well as controlling and management strategies at communal or government level. Information obtained from the key informants was collected with an audio-recorder.

Respondents to the questionnaire were above 18 years, mostly male (52.2%), and 62% of the survey population have lived in Ijebuland for at least 5 years. Over 52.8% were married (Table 1). Eight out of 12 of the key informants were male, and have resided in the community for a at least 10 consecutive years, but the two officers of the OSADA were male. Each participant responded to their perception on land conversion, water resources and agricultural land area.

5.4 Data analysis

Information obtained from residents was analyzed using frequency and percentage with the description of absolute mean, while responses from KII were analyzed using thematic content analysis approach. Respondents' perceptions were comparatively examined with the results of the landuse/landcover as has been employed in many studies (e.g., Banerjee, 2015; Eludoyin et al., 2017; Murtinho et al., 2013; Prasad & Shiba, 2016; Toan et al., 2014). Murtinho et al. (2013) argued that such approach of comparative examination of social survey and satellite data analysis complements missing recorded data and allows for better predictions. Such a method, which infuses quantitative and qualitative approaches, also bridges the gaps between observed and experimental representations and provides opportunities to appreciate the impact of indigenous or local knowledge as well (Banerjee, 2015). The weights of the effects of urban expansion, in terms of the amount of built-up areas, were quantifiably examined with linear regression. Water bodies were digitized from the classified image of the study area.

6 Results

6.1 Change in landuse/cover

Results of the land cover change analysis showed that the area, which was dominated by forest in 1986, became dominated by farmland in 2000, and later by built-up areas in 2016 (Fig. 2). The forested area had declined by 20.3% between 1986 and 2000, and further by about 6.5% by 2016. On the other hand, farmland increased by about 8% in the 1986–2000 period, and 2.9% thereafter while built-up areas have increased by 212.3% (32,858.48–102,611.74 ha) between 1986 and 2016 (Fig. 3). Open areas that have increased

Table 1 Composition of respondents in Ijebuland

Characteristics	Options	Local government areas (LGAs) (%)						
		Ijebu-East	Sagamu	Odogbolu	Ijebu North	Ijebu-Ode	Ijebu North East	Overall
Gender	Male	39	81	50	109	63	34	376
	Female	40	104	40	94	50	16	344
Age group (years)	<21	7	17	8	20	4	2	58
	21–45	18	56	20	83	51	8	176
	46–60	38	58	26	54	40	34	250
	>60	16	54	36	46	18	6	236
Religion	Islam	34	92	36	88	44	24	318
	Christianity	32	76	48	95	64	24	338
	African traditional religion	9	17	6	14	2	2	50
	Undeclared	4	0	0	6	5	0	14
Marital status	Married	39	79	46	112	62	32	380
	Single	26	48	22	41	39	7	178
	Divorced	12	20	18	28	7	6	88
	Widowed	2	38	4	22	7	5	74
Length of residence (years)	<1	12	32	22	27	9	10	112
	1–5	14	30	22	50	40	6	162
	6–10	16	44	18	52	24	6	160
	>10	37	79	30	54	40	28	286
N		79	185	90	203	113	50	720
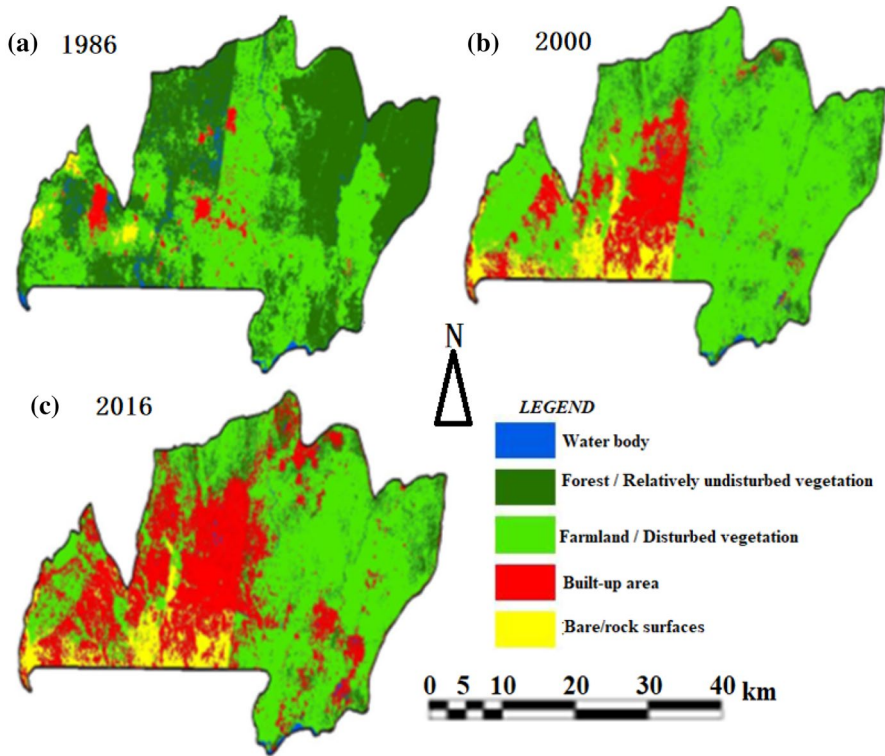
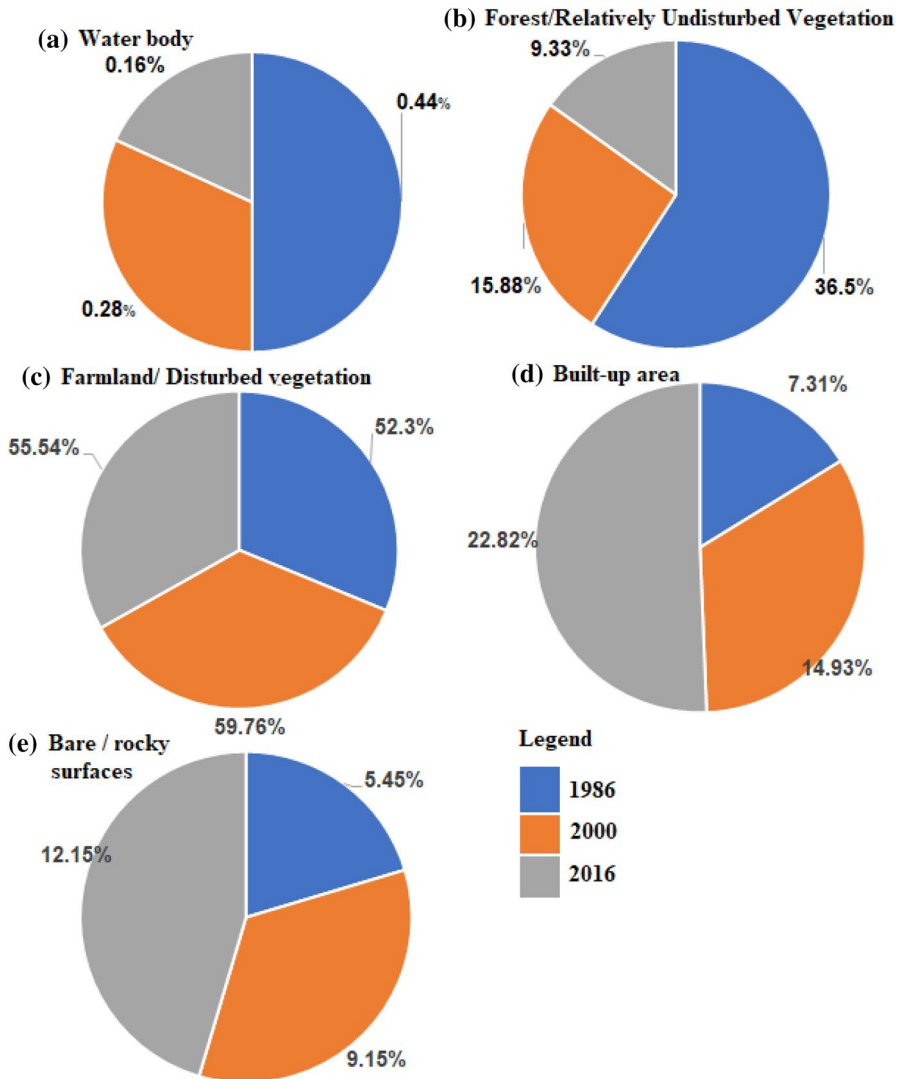**Fig. 2** Changes in land cover and uses over Ijebuland

by 5.7% and 3% in 1986–2000 and 2000–2016 periods suggest loss in previously vegetated areas, probably due to increased pressure for farmland or built-up, or both (Fig. 4). Area covered by water (drainage) reduced by 64% (from 1990.1 ha in 1986 to 713.9 ha in 2016). In terms of NDVI, results suggest significant decline in the greening (indicating loss of vegetal cover) from 53.2% in 1986 to 10.1% in 2016 (Fig. 5).

Furthermore, 85.9% of the residents attributed land cover/use change in the study area to population increase but in parts of Ijebu East and Ijebu North LGAs, participants in the FGD argued that

> most of our able-bodied young men and women have left our villages in search of white-collar jobs in surrounding cities and towns.

Further interrogation of the perception of the FG Discussants in the LGAs suggests spatial dimensions, especially among rural and urban dwellers. For example, in Ijebu-Ode and Ijebu-North East LGAs that are more urbanized, and where population influx has been reportedly profound since 2000, one of the discussants (in Atan, Ijebu-North East LGA) argued that

> there has been influx of people into Atan community due to its proximity to Ijebu-Ode. Although most of them work in Ijebu-Ode and some even in Lagos, it is easier to get accommodation here especially as other areas are faced with housing congestion.

Fig. 3 Percentage changes in land cover and uses over Ijebuland, Nigeria

Several reasons were given for conversion of vegetated areas to other uses. Some of the key informants who were farmers claimed to have sold fragments of their farmlands at one point or the other for residential or other construction purposes. A community head in Ijebu North East LGA stated thus:

> I am guilty because I once sold a large part of my land to some civil servants who converted the land to residential use. There was little or no choice as I had no money with me when one of my sons gained admission into the university.
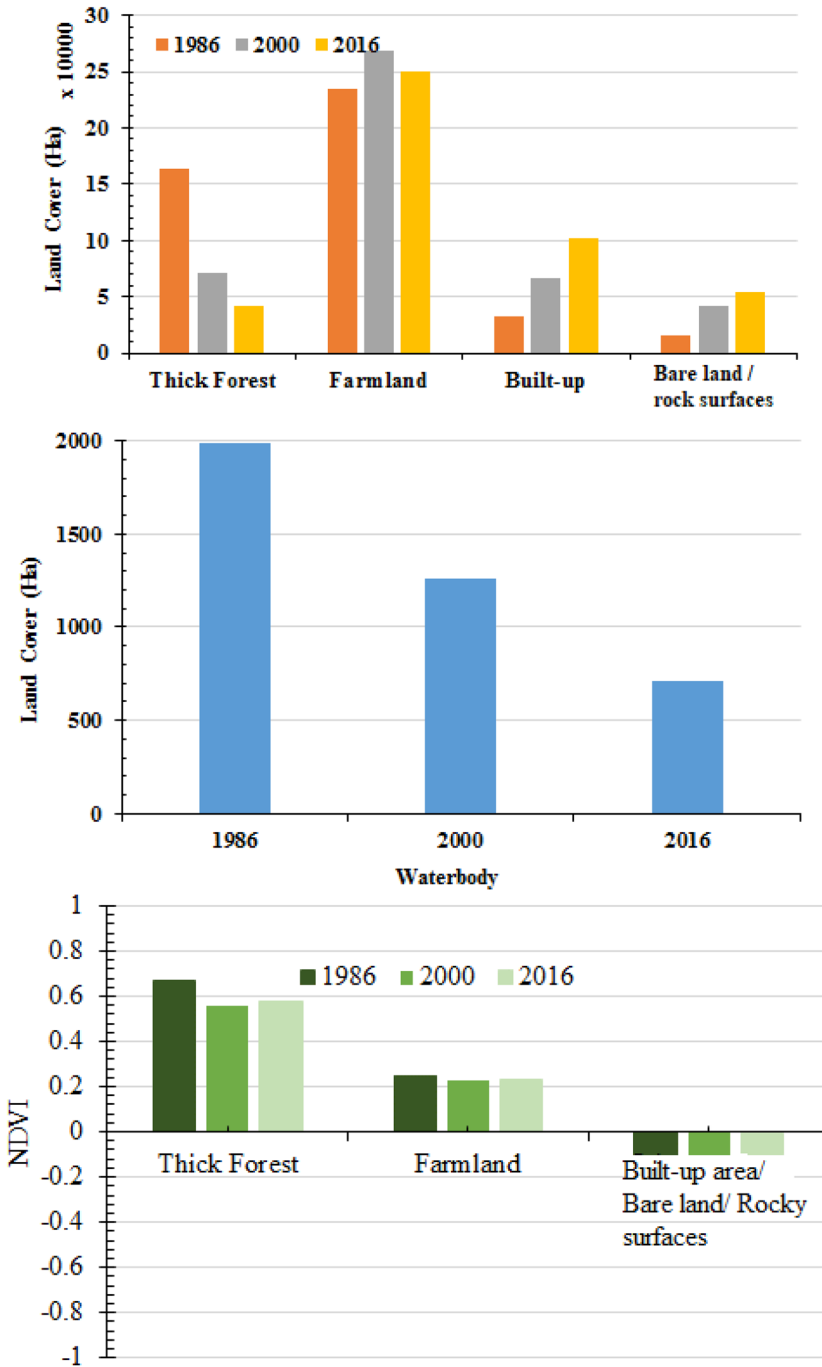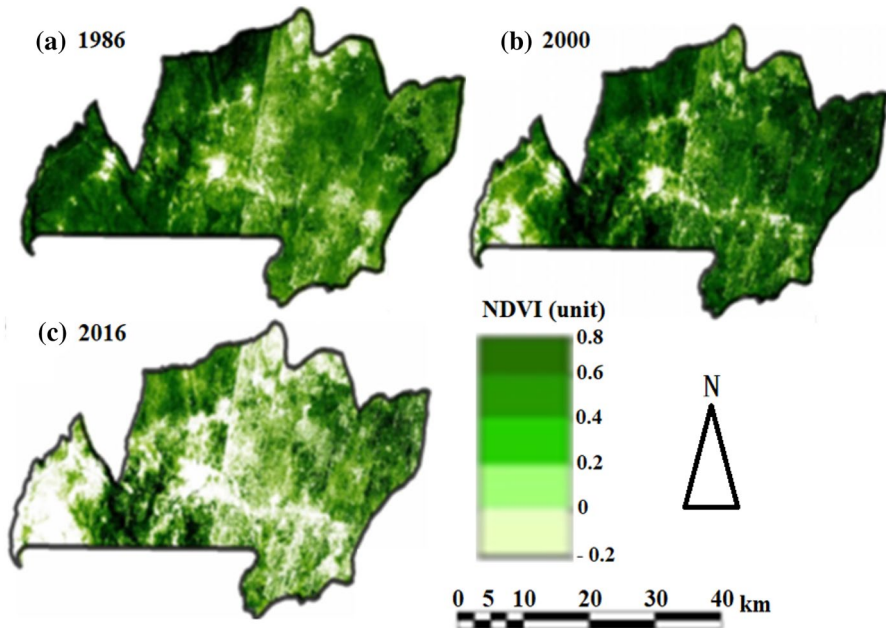
Fig. 4 Variations in area cover by different landuses/cover between 1986 and 2016 in the study area

Fig. 5 Changes in vegetation health status indicator, Normalized Difference Vegetation Index over the study area between 1986 and 2016

Corroborating this, the opinion of most participants at the FGDs showed that land conversion to other uses has increased. They noted that many farmers have abandoned cocoa and kola nut farming for other crops like cassava, maize, vegetables and other crops which have smaller maturity period. Farmer F8 in Ajebamdele, Ijebu-East LGA argued that:

> Although I have not totally converted the whole of my land to other use, I have apportioned a fragment of it for cucumber and vegetables because they mature faster and I get my returns quicker than I do on cocoa and kolanut.

In addition, farmers and residents around Sagamu LGA also reiterated that they have had reasons to part with portions of their farmlands for some environmental, economic and financial reasons (Fig. 6).

6.2 Change in water resources

The area covered by waterbodies decreased as built-up areas increased; almost disappearing by 2016 (Fig. 5). For example, the total area covered by pools of water reduced from 1990.11 ha (or 0.44% of total land area) in 1986 to 713.85 (or 0.16% of total land area) in 2016. This amounted to 64.13% reduction in water resources of the area. Also, about 62% of the residents perceived that size and number of streams, rainfall amount and frequency of raining days have declined during the study period (Fig. 7). On the effects of urban growth and development on water resources, most residents (68.5%) believed that proliferation of houses and other forms of urban development have adversely affected water
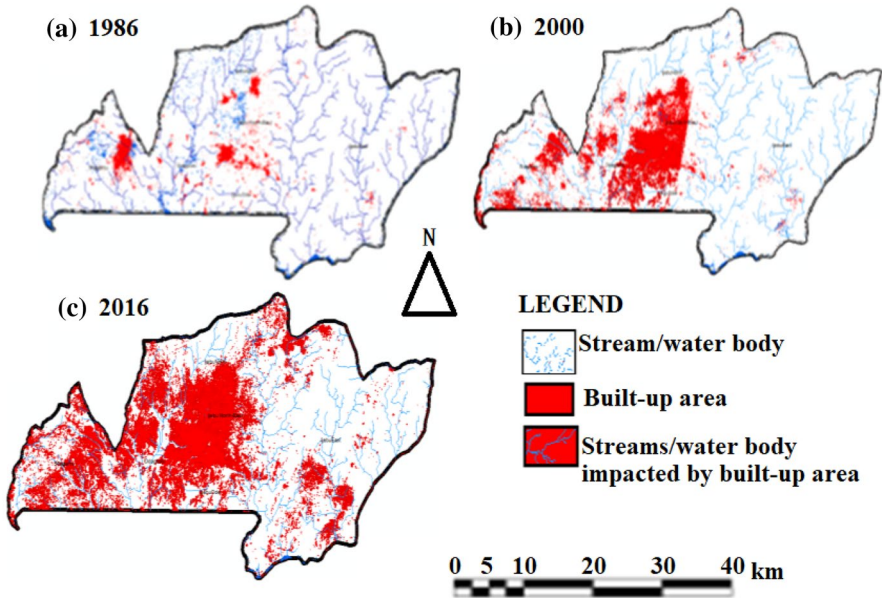
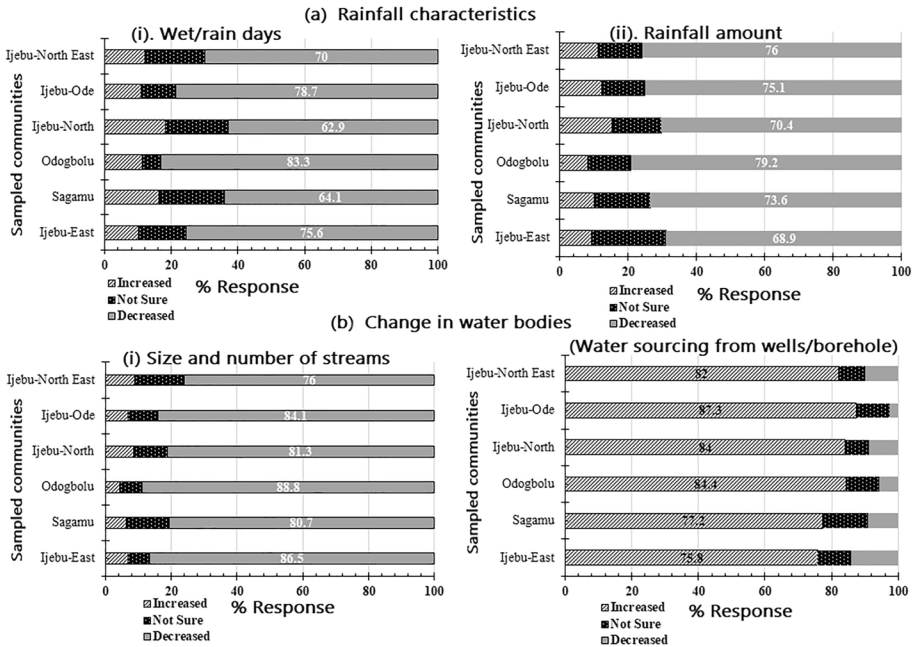**Fig. 6** Change in water bodies alongside built-up areas

Fig. 7 Perception of residents on rainfall characteristics and effects of urbanization on water bodies

resources and have also polluted existing ones. They also noted that these have increased pressure on water utilization leading to water scarcity (74.4%). Other factors suggested by the respondents to have affected water resources include soil erosion and over flooding. This has also led to several social challenges such as walking long distances to fetch water and subjecting children especially girls to undue pressures in search of water. When asked of measures being taken to cope with these pressures, more than 60% of respondents in all the LGAs asserted that boreholes and hand-dug wells are sunk indiscriminately by communities and households as a response to the growing water scarcity in the area. Other measures taken to cope with water scarcity include rain water harvesting and provision of large storage tanks.

Furthermore, all participants of the KII agreed that water resources available in Ijebuland are used for several purposes such as drinking, farming and recreation. On the sources of water resources in the area, it was agreed that the major water bodies in the region serving these purposes are Odo Owa, Soyindo, Eruwuru, Yemoji and Majopa streams in Ijebu North, Ijebu-Ode and Sagamu LGAs, respectively. On the changes in the size and number of these water resources, it was agreed that while the sizes of the major sources have decreased, several smaller sources have disappeared. For example, a key informant at the Ogun State Agricultural Development Agency (OSAPA) argued that

> a number of water bodies are drying up already…Years ago, there were many rivers that were perennial, serving agricultural and domestic purposes. These rivers are now at best intermittent; flowing at much reduced volume in rainy season and dries off in dry season. This affects water supply to close farmlands causing such farmers to either suspend planting of crops till rainy season or seek other sources of water for irrigation.

Also, community heads in Ijebu Ode, Ijebu North, Ijebu-Ode and Sagamu LGAs cited as an example one of the streams well known for its recreation purpose is the Yemoji Stream. The stream in Imagbon village, Ijebu-Ode LGA which for long was a major water transportation route for farm produce to neighboring villages, and an important source of household water supply for residents in the area has reduced in size in recent times. Also, rather than use for transportation, it is merely used for recreational purpose.

On the coping strategies adopted by farmers to the reduction in water resources, all the participants said those that have sufficient money sink boreholes and install pumping machines while those that cannot afford those dig wells or resort to manual watering of farms. However, most of these challenges occur in the dry season as explained by a community head in Ijebu North:

> we usually do not have problems with water availability in the rainy season because we can harvest rain water. However, in the dry season, since quite a number of house owners have boreholes, residents without boreholes do not really have to walk far distances to get water. In fact, some people are so generous that they have specific time (usually in the evening) when residents can fetch water easily.

On participants views on other problems associated with waterbodies, there was a consensus that inappropriate waste disposal is polluting existing water bodies. For instance, in Aruba, Sabo and Sagamu LGAs, example was cited of the degradation of Eruwuru stream through pollution emanating from direct dumping of domestic and poultry wastes into the water body. In terms of rainfall amount, over 75% of participants perceived that rainfall quantity and frequency of rainy days have drastically reduced in their localities. The other 25% noted that rather than a reduction in rainfall, rainfall onset and cessation periods

Table 2 Change in selected landuse/cover

Land use/cover	Trend	R^2	F-value	F-probability
Built-up area	$-2132.7 + 34,842x$	0.58	3058.4	0.01
Water bodies	$2610.5 - 643.5x$	0.10	242.4	0.03
Farmland	$103,692 - 1784.7x$	0.47	1948.0	0.01
Cash crops (cocoa and kola) farms	$166,442 - 36,217x$	0.27	821.8	0.02
Forest	$125,699 - 23,527x$	0.92	25,187.1	0.02

Table 3 Contributions of rainfall and temperature to change in land cover/uses and water bodies

Landuse/cover	Rainfall (x_1)	R^2	Temperature (x_2)	R^2	Combined effect (temperature and rainfall)	R^2
Land area	$36,212.8 - 0.3x_1$	0.01	$41,980.8 - 0.008x_2$	0.00	$43,695.1 - 1.9x_1 - 0.01x_2$	0.001
Water bodies*	$9.2 + 0.1x_1$	0.26*	$100.4 - 0.35x_2$	0.12	$50.3 + 0.5x_1 - 1.4x_2$	0.29*
Built-up area	$10,987.6 + 0.08x_1$	0.01	$-12,228.4 + 0.33x_2$	0.11	$-21,049.0 + 0.26x_1 + 0.43x_2$	0.16
Farmland	$154,312.3 + 0.05x_1$	0.002	$134,711.6 + 0.13x_2$	0.02	$125,666.0 + 0.12x_1 + 0.18x_2$	0.03
Forest	$295,114.5 - 0.36x_1$	0.13	$90,185.8 - 0.10x_2$	0.1	$37,799.2 - 0.29x_1 - 0.48x_2$	0.2

*Asterisked landuse/cover was more influenced by rainfall and temperature than others

have become more unstable and difficult to predict. While the participants were aware that unstable rainfall events portend negative effects on farming, especially during the early stage of crop growth, they were ignorant of the effects of climate change and could therefore not proffer any reason for the changes they observed in rainfall patterns. On how they managed the effects of changes in rainfall pattern, they agreed that digging of boreholes and hand dug wells were the best options available.

6.3 Effects on landuse/land cover and water resources

In terms of evaluation of the changing patterns of the land use and yield variables, the interactive model revealed that whereas built-up areas (x_3) exhibited an increasing change over time ($b = 0.113$; $p < 0.001$), the forest (x_1; $b = -1.150$; $p < 0.001$), water bodies (x_6; $b = -0.013$; $p < 0.001$), farmland (x_2; $b = -0.283$, $p < 0.001$), and agricultural land area exhibited significant decline over time (Eq. 1). The changes were significant for combined effects at 95% confidence level ($F = 8794.4$, $p = 0.02$, coefficient of determination; $R^2 = 0.96$).

$$y = 74.592 - 1.150(x_1) - 0.283(x_2) + 0.113(x_3) - 0.076(x_4) - 0.029(x_5) - 0.013(x_6)$$
(1)

where x_1 = forest (Ha), x_2 = farmland (Ha), x_3 = built-up areas (Ha), x_5 = agricultural land area (Ha), x_6 = water resources (Ha), y = year (in nth, where 1986 = 1).

Although the results of the interactive models suggest that water resources least changed over time, simple linear regression analysis of individual variable indicated that the result

of the water resources may have been influenced by its relatively lower values than the other variables (Table 2). Analysis of the relationship of the landuse/cover activities with rainfall and temperature, however, suggests that the climatic effects were less significant than the human factors (compare the coefficient of determination (R^2) of built-up area in Table 2 with that of the climate variables in Table 3). The coefficient of determination of the relationship of either the land area, built-up area, water resources, farmland or forest in the study area with each other or both of rainfall and temperature was less than 0.3. The results of the R^2 indicated that less than 30% of the change in each of the land classes had resulted from either or both of rainfall and temperature. The result of dendrogram that was used to graphically express the clustering pattern of the variables indicates a stronger bond between water resources and built-up area, on the one hand, and water resources and land area, other hand than with either the farmland or forest (Fig. 8).

In general, an evaluation of the mix of perceptions and inferential analysis of image (Landsat) data, and crop (cocoa and kola nut) yield indicated that increase in urban areas caused significant reduction in size of vegetated areas and space available for fallowing agricultural system, and that parts of river basins have been occupied by buildings and other structural development. Also, this shows that most of the coping strategies adopted by the residents to cope with the increase in built-up spaces and corresponding degradation of water resources and forest are rather reactive rather than preventive, and are therefore not
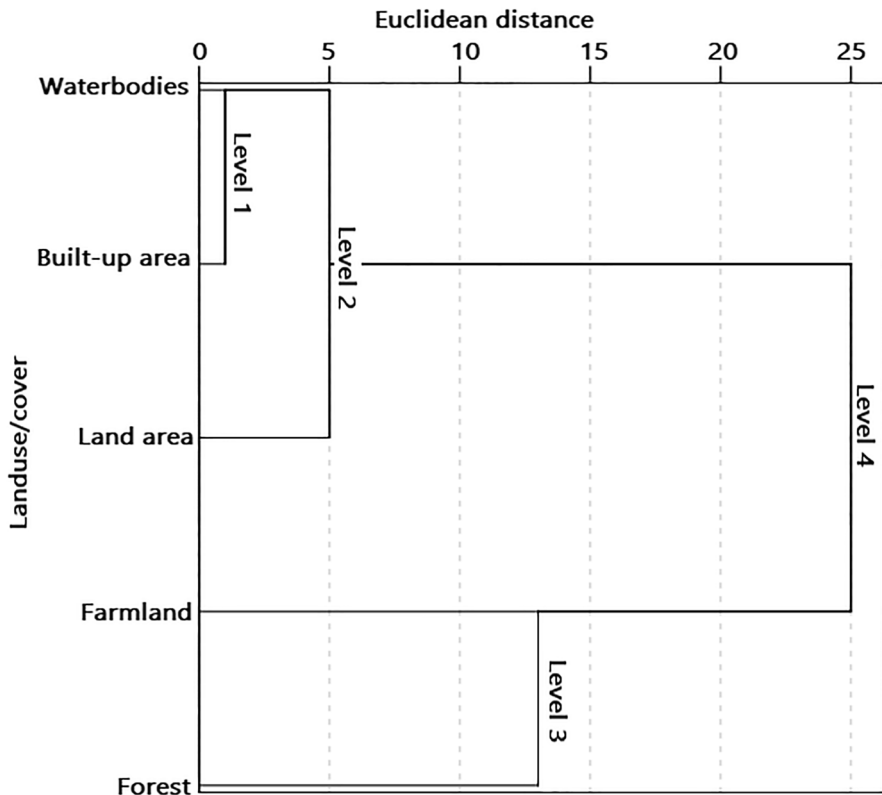
Fig. 8 Dendrogram (hierarchical cluster) showing the relationship among landuse/cover in Ijebuland between 1986 and 2016
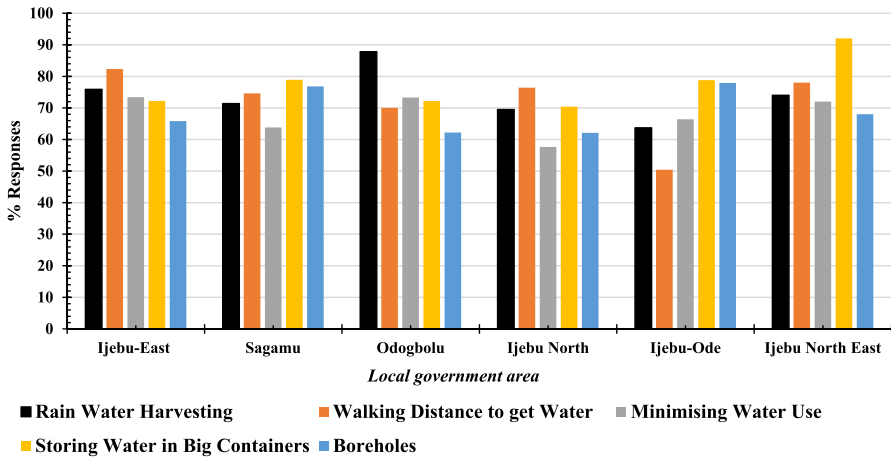
Fig. 9 Responses to the water problems that were attributed to urbanization

likely to be sustainable (Fig. 9). For example, coping strategies for loss of water resources include the use of boreholes, which were not reportedly used for irrigation purposes. Residents who were previously farmers changed jobs and/or migrated into other cities as a coping strategy for land conversion, and there apparently seems not to be any meaningful coping strategy for declining agricultural land.

7 Discussion

This study analyzed the effects of urbanization on land conversion dynamics and water resources in Ijebuland between 1986 and 2016. The findings of this study revealed significant increase in built-up areas and significant decrease in vegetation cover across the areas investigated over the study period (1986–2016). Built-up areas increased from 32,858.48 ha of 449,657.12 ha of the total land area (7.13%) in 1986 to 102,611.75 ha (22.82%) in 2016. Conversely, vegetation cover decreased from 164,128.55 ha (36.50%) in 1986 to 41,969.45 ha (9.33%) in 2016, i.e., more than fourfold decrease over the 30-year study period. These findings are consistent with earlier findings in the area, though the rate of land conversion appears to be increasing (Bakare et al., 2011). Adeleke and Orimoogunje (2016) reported a much higher increase in Abeokuta, Ogun State (sixfolds) between 1972 and 1984. Although the difference in the rate of increase in built-up area between the two study areas cannot be easily explained, Abeokuta became the State Capital of Ogun State during the earlier study and this probably accounted for the faster rate in development. Olujide et al. (2018) carried out a similar investigation in Akure, Capital of Ondo State between 1991 and 2016 and recorded a change from 27.62 to 210.47 km^2 in 2016 within the study period. This level of change is closer to what was obtained at Abeokuta confirming earlier suggestion that political status of a city affects the rate of change of infrastructural development.

This study also revealed that the observed changes in the built-up area may have potential harmful effects on the environment. This conclusion is in line with the findings of Senjobi and Ogunkunle (2011) which opined that indiscriminate conversion of land resources

to buildings and arable crop farming will lead to depletion and degradation of the environment. Similarly, Bakare et al. (2011) noted that the wetland in Ijebu-Ode had witnessed tremendous changes due to infilling of wetland for infrastructural development and this has resulted in loss of biodiversity, invasion by alien plant species and pollution of the wetland. These findings were in agreement with reports from different parts of Nigeria including Lagos (Okude & Ademiluyi, 2006; Taiwo & Areola, 2009) and Kaduna (Saleh et al., 2014). Outside Nigeria, the trend of land use/land cover change was similar to the findings of this study Abonyo et al. (2007) reported a decrease in grasslands and forest areas between 1960 and 2006 and attributed this trend to increasing rate of urbanization in Kampala, Uganda. Yesmin et al. (2014) also revealed reduction in forest cover while built-up areas and bare lands were found to increase. The findings of both this and previous studies show that urban land use/cover dynamics exhibit the same pattern and trend over the study period throughout the reviewed regions of the world.

These changes were well recognized by both residents and farmers in the study area. Over two-third of the FGD participants attested that to a significant reduction in vegetation cover and expressed worry at the trend but they were more concerned about its effects on availability of farmland and its proceeds than on the environment. The participants attributed this trend to the quest to build more houses but disagreed that increasing population is a contributory factor. These findings appear to indicate that while the participants were very much aware of land use and land cover changes in their area, they are ignorant of the negative effect of unchecked population growth. Studies from other regions (e.g., Abonyo et al., 2007; Bokhari et al., 2018) have also observed that residents perceived that land resources and vegetation are negatively affected by urbanization.

The findings of this study also revealed significant decrease in water resources, over the study period (1986–2016). Water resources reduced from 1259.06 ha (0.44%) of 449,657.12 ha of the total land area in 1986 to 713.85 ha (0.16%) in 2016, i.e., 76.4%, decrease over the 30-year study period. There was evidence that these water resources were converted to infrastructural development. This finding could be explained by the rate of increase in built-up areas and the effect of climate change. This is in line with the general perception of farmers at the FGD sessions that water resources have reduced in their locality, and in some cases, some rivers have dried up. The trend also agrees with the findings of Ayivor and Gordon (2012) which investigated most river basins in Ghana and found that several of them are shrinking as a result of land use/land cover changes. The major land use/land cover types reported to affect the basins were urban development, agriculture, residential, fishing and transportation. Also, Sharma et al. (2017) reviewed the effects of land use/land cover change on water resources and concluded that enlargement of the urban area results in decrease in surface water and infiltration which affects ground water recharge and storage. These findings corroborate numerous other studies in different parts of the world, e.g., in Tanzania (Mahoo et al., 2007); India (Karthiyayini & Sundaram, 2016); Kenya (Ochenje et al., 2016); Pakistan (Rashid et al., 2018) and Georgia (Withanachchi et al., 2018). The study also found that farmers were aware of decline in the size and number of surface water in the study area over the study periods. They attributed the trend to urban development but were ignorant of the effects of famine of surface water siltation.

On the other hands, evidence from this study suggests that the observed changes in water cannot be solely attributed to urban development but may have also been affected by climate change. While the degree to which this pattern has affected the observed decrease in water resources was not clear, it will be important for this to be investigated in the future. Such investigation will help to unravel the best scientific methods of coping with climate change effects on water resources. This is important because the current coping strategies
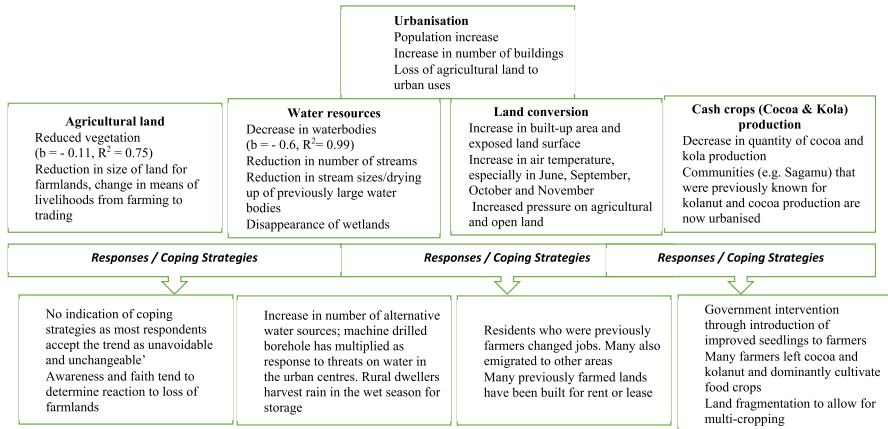
Fig. 10 Effects of urbanization on water resources, agricultural land area and crop yield, and residents' coping strategies in Ijebuland, Nigeria

such as digging of wells and boreholes adopted by the residents and farmers are not only tedious and expensive, they are also unsustainable.

The relationship between urbanization, agricultural land, forests, farmland and water resources has been analyzed singularly in several studies; and all of these factors are affected by human activities through rapid urbanization, industrialization and rural land conversion. This study observed that a growth in built-up areas affects the environment (Fig. 10). This finding is supported by several studies that most urban cities are unsustainably encroaching forest resources in their areas of study (Adedeji & Adeofun, 2014; Jibrillah, 2019; Manik & Sidle, 2018; Mohajane et al., 2018; Ushie & Eludoyin, 2019). From the regression model presented in this study, built-up area which was about 7.1% of the total Ijebuland area in 1986 rose to about 25% of the land area in 2016 and is estimated to occupy about 50% of the total land area between 2063 and 2064, unless drastic measure were taken to tame the tide. Similarly, vegetative cover in the area will follow a reverse trend and decrease at a corresponding rate. These findings are in agreement with Cui and Shi (2012) that analyzed the processes and characteristics of urbanization in Shanghai, focusing on its effects on crop land and forest land. The study concluded that the growth of Shanghai has been driven by the continuous increase of buildings, paved roads, buses, population and GDP, as well as the decrease of cultivated land.

The observed decrease in agricultural land over the years is also in consonance with the findings of d'Amour et al. (2017) which reviewed global trend in the loss of croplands due to urbanization and found that over 80% of cropland lost to urbanization worldwide occurred in Asia and Africa with Africa being the most affected. The result of multiple regression in the present study suggests that at the rate of (-0.03) for every unit increase in built-up areas, the current agricultural land will disappear by 2030. It calls for urgent drastic actions to protect croplands in Ijebuland to ensure sustainable development for the future. At the current rate of agricultural production, compared with 1986 level, the results of multiple regression also show that by 2050, Ijebuland will no longer be a major agrarian community producing region. This scenario clearly portrays the fears expressed by both residents and farmers in the study area that all resources related to forests are gradually depreciating. In spite of the worsening scenario for agriculture, the residents showed very

strong resilience in their ability to cope with the situation suggesting that the future may not be as bleak as the projections of this study. In addition, some of these services in the urban areas serve as growth poles which attract these migrants, siphoning raw materials and income from the rural areas to urban areas therefore impoverishing the rural areas further. Although, to the advantage of urban areas is development, it is apparent that deforestation and biodiversity loss caused by such development encourage extreme climatic condition, loss and pollution of water bodies and other environmental problems.

8 Conclusion

Main findings of the study showed significant spatial and temporal changes in dominant landuses, and indicate 130.3% loss in total agricultural land, 27.17% reduction in forest and 0.28% water resources, respectively, between 1986 and 2016. At least 70% of the residents perceived that whereas urban population has increased, farm areas and drainage basins have declined. Responses of the residents and key informants as observed in this study provided explanations to key changes observed in the satellite data. The usefulness of satellite data in this study was limited by their availability, which accounted for the data gaps in the dates of the satellite data (1986, 2000 and 2016). Whereas less coarse datasets, with better (higher) resolution (than 38.5 m for Landsat) were preferred, Landsat data were part of the few freely available ones (and this is a huge factor for many researchers from developing countries, whose studies rarely received sponsorship) that have been found relevant to land use/cover change in Africa. This study assumed that the local people, especially adults (above 18 years old), including society leaders and government employees, that have lived in the study area for at least 10 years were capable of providing reliable information about change in land cover and use in their surrounding as at the period of their stay. Results of social surveys, when complementarily investigated with satellite and long-term climate data, showed capacity for better explanation of environmental changes than any of the dataset, separately. Statistical models developed in the study also showed a systematic interaction between urban development and the selected variables of the ecosystem (water resources, and forest vegetation). Information relevant to sustainable regional and national planning can be harnessed with improvement in capacity for data collection, analysis and modeling. The increasingly threatening effects of urbanization on land resources and water bodies observed in the study area should encourage prioritization of effective policy-driven sustainable plans for urban planning, improved early warning and coping systems for climate extreme and ecosystem degradation in the region, and other parts of the sub-Saharan Africa with similar records of urban growth.

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