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The implications of land use land cover change in Ede wetlands, Southwestern, Nigeria on global climate change

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Abstract

The study assesses the factors influencing the use of wetland resources, with a view to ascertaining the extent of land use /land cover change (LULC) and its implications on Global climate change. Landsat TM 1986 and ETM+2002 satellite imageries were processed using digital image processing techniques to capture the various land use/land covers and change detection. The result shows that wetlands were 2587.93ha in 1986 but were reduced to 889.66ha in 2002 while dense forests were also reduced from 6496.41ha in 1986 to 5388.26ha in 2002. Similarly, settlements increased from 530.42ha in 1986 to 762.95ha in 2002 while derived savannah/farmland also increased from 2684.04ha in 1986 to 3260.87ha in 2002. It was therefore projected that given the high rate of land use conversion; wetlands could be further reduced to 461.67ha by 2018. The study concluded that anthropogenic activities have seriously encroached on the forests, water bodies and wetlands in the study area which have in turn negatively impacted on the global climate.

Keywords: Wetlands; LULC; Land Use Planning; Climate Change; Anthropogenic Activities

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1. Introduction

Land use change is one of the dynamic activities which is continuous and ongoing shaping the human environment positively and negatively. Land is the stage on which all human activities are conducted and the source of the materials needed for this conduct (Briassoulis, 2000). Human use of land resources give rise to ‘‘land use’’ which varies with the purposes it serves; whether for food production, provision of shelter, recreation, extraction and processing of materials, and so on, as well as the bio-physical characteristics of land itself. Hence, land use is being shaped under the influence of two broad sets of forces which are ‘‘human needs’’ and ‘‘environmental features and processes’’ (Briassoulis, 2000). Apart from air and the sea, almost all other natural resources such as forest, grassland, solid, fossil and gaseous minerals, agriculture, wetlands, soil and water bodies just to name but a few are located on land. It has also been observed that land seems to be the most valuable asset at the disposal of the grass root people to meet their developmental needs for housing as well as agriculture. For instance, over 60 percent of the population of West and Central Africa is dependent on land for subsistence or commercial agricultural production (Gasu, 2011). The complex set of dynamic interactions between land use and human society has environmental consequences and that is because the common attributes of land are inherently unique. For instance, land is almost fixed in location (or limited in amount and exhaustible), it is subject to competing uses and change values (Agbola, 2008). It is therefore, for this reason and many more that the harmonious and judicious use of land is advocated through land use planning.

It has generally been accepted that land use/land cover change (LULC) is a key driver to global change which has significant implications on many international policy issues (Mengistu and Salami, 2007; Vitousek, 1992). Studies on land use/land cover are beginning to take the centre stage of most human discussions because nations of the world are poised to overcome the problems confronting them as a result of their inability to properly harness their resources (Agbola, 2008) and create a conducive living environment for living, working and recreation. The importance of land use/land cover has equally been echoed by Turner et al. (1995) who observed that nations of the world are increasingly becoming aware of the challenges of haphazard and uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, loss of fish and wildlife. In an attempt to quantify and qualify land use/land cover change, several studies have been undertaken but remote sensing and Geographic information system appears to be making the most significant contribution at regional and global scales beginning from the mid-1970s (Lambin et al., 2003).

According to Mengistu and Salami (2007) to understand how LULC changes affect and interact with global earth system, information is needed on what changes occur, where and when they occur, the rates at which they occur, and the social and physical forces that drive those changes (Geist and Lambin, 2002). These changes ultimately impinge on human welfare and climate change thereby, generating a lot of concerns for land use planners and other developmental experts. Since these changes occur at different spatial and time frames, remote sensing and GIS is gradually emerging as one of the leading tools capable of quantifying these changes which is equally generating a lot of interests. Mengistu and Salami (2007) observed further that several studies have been conducted in South Western Nigeria using geospatial techniques for instance Adejuwon and Jeje

(1973) mapped vegetation/land use associations in Ife area using 1:40,000 panchromatic photogrpahs while recent studies includes; Salami (1999), Salami et al. (1999) who carried out landuse/land cover change using satellite images. More recent studies in this region include; Salami and Akinyede (2006) on Land use/land cover change using data from Nigeriasat-1 of 2004 and landsat image of 1986 and Amomoo et al. 1998 used satellite image to differentiate built up from non built up landuse for population census base map revision. It could however be observed that all these studies did not consider wetlands as an important land use function despite its importance on the human society for flood control, water quality enhancement, ground water recharge, socio cultural, aesthetics as well as environmental functions and also as support to all forms of live.

The concern about the environment today, highlighted by the recent rapid growth of the world's human population which has put pressure on natural resources, the increasing socio-economic interdependence of countries and regions, the growing awareness of the value of natural ecosystems and the perception that current land use practices may influence the global climatic system, has further widened the scope and operation of land use planning (Agbola, 2008). Therefore, land use planning today is a tool for decision making process that "facilitates the allocation of land to uses that provide the greatest sustainable benefits" (Agenda 21, paragraph 10.5 quoted in Agbola, 2008). Similarly, Agbola (2008) while quoting Barry et al. (2007) noted that the global environmental change questions, such as global climate system – warmer temperature, rising sea levels and potentially more frequent and severe extreme weather events such as hurricanes and tropical storms, ozone layer depletion, green house effects and other negative effects of climate variability, have been traced to land use practices and subsequent land use land cover change.

Four broad categories of land use changes leading to climate change include; proximate causes such as; agricultural expansion, wood extraction, infrastructure extension and other factors (Figure 1). Furthermore, the underlying driving forces could be divided into five broad clusters such as Demography, Economic, Technological, Policy and Institutional and Cultural factors which were equally further sub-divided into Natural Increment, Market Growth and Commercialization, Agro-technical Change, Formal Policies and Public Attitudes, Values and Beliefs respectively (Agbola, 2008).

The causal factors were quantified by determining the most frequent proximate and underlying factors as well as the factors that commonly lead to deforestation. Similarly, Geist and Lambin (2002) distinguished three modes of causation from their studies as follows (Figure 1):

- Single factor causation – i.e. one individual underlying factor driving one or more proximate factors.
- Chain – logical causation – i.e. several interlinked factors, which in combination lead to deforestation.
- Concomitant occurrence – i.e. independent, separate operation of factors causing deforestation (Agbola, 2008).

Land use/land cover classification (LULC) using remote sensing offers one of the most universally acceptable techniques in determining the evolution and the actual state of land use/land cover resources in our immediate environment. There is also the dearth of information on LULC which can aid planning, environmental monitoring and the decision making process especially on wetlands. It was at the backdrop of all these that this study was conceived to examine the factors influencing the use of wetland resources, with a view to ascertaining the extent of land use /land cover (LULC) and change detection and its impact on Global Climate Change.

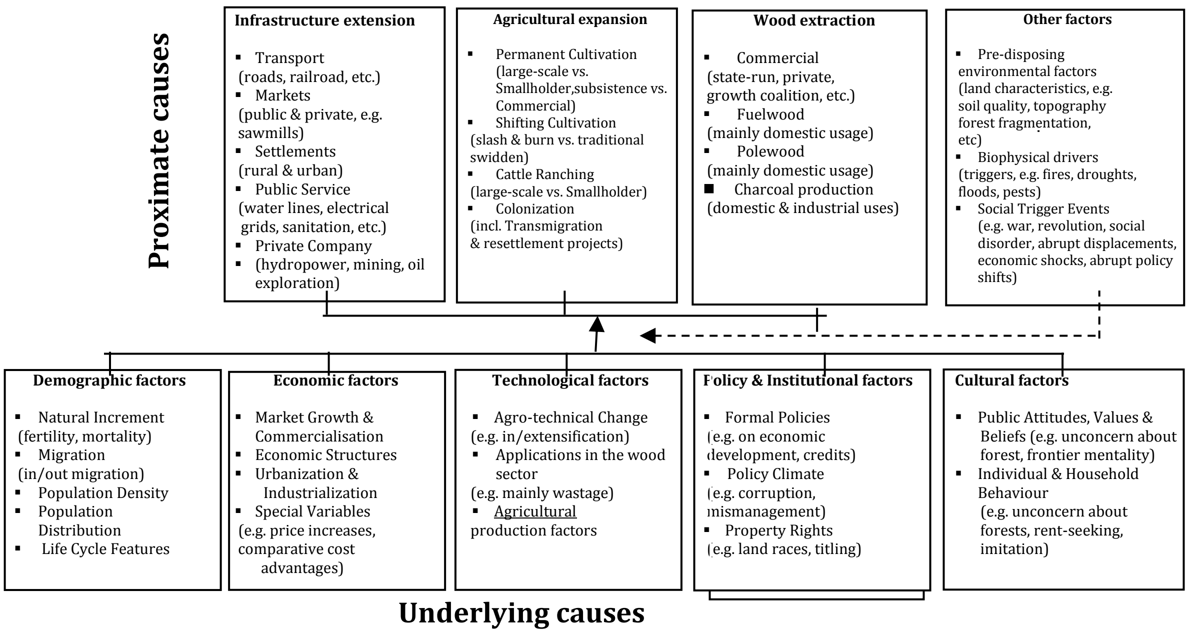

Figure 1. Causes of Landuse and Landcover Changes. (Source: Adapted from Geist and Lambin, 2002 in Agbola, 2008)

1.1. Climate Change

Climate Change (CC) is the consequence of the release of Green House Gases (GHGs) into the atmosphere by inconsiderable activities of man on the environment, which in turn creates the enhanced greenhouse effect by an increase in the earth's average temperature. Climate change or global warming is mainly caused by the presence in the atmosphere of carbon dioxide (CO_2), methane (CH_4), water vapour, ozone (O_2) and nitrous oxides (N_2O) emitted from wetlands destruction and other anthropogenic sources. These pollutants trap long wave radiation re-emitted by the earth's surface and prevent it from escaping back into the outer space thereby causing the earth to warm (the greenhouse effect) (Gasu et al., 2010). Oseni (2016) noted that Intergovernmental Panel on Climate Change (IPCC) predicted that the average global temperatures could increase to between 1.4 and 4.5^0 C by the year 2100. In addition, the growing atmospheric concentrations of halocarbons and nitrous oxides has also intensified the "greenhouse effect" (Mukherjee, 2002). The United Nations Framework Convention on Climate Change 1992 defines CC as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time period" (UNEP, 2002; Fadare et al., 2010). Climate change affects the warming and acidification of the global ocean; it influences the earth's surface temperature, the amount, timing and intensity of precipitation, including storms and droughts. On land these changes affect fresh water availability and quality, surface water runoff and ground water recharge, the spread of water borne disease vectors and it is likely to play an increasing role in driving changes in biodiversity and species distribution and relative abundance (GEO_4, 2007).

Akinola (2012) reported that in West Africa, in 2010, the number of people that died due to flood resulting from climate change was highest in Nigeria with (118), followed by Ghana (52), Sudan (50), Benin Republic (43), Chad (24), Mauritania (21), Burkina Faso(16), Cameroon (13), Gambia (12), with other countries reporting less than 10 dead. Similarly, about 1.5milion people were affected: most of them in Benin Republic (360,000), followed by Nigeria (300,000), Niger (226,611), Chad (150,000), Burkina Faso (105,481), Sudan (74,970) and Mauritania (50,815). Other countries had less than 50,000 people who suffered from floods. The floods resulted in cholera epidemics which claimed 1,182 lives in Nigeria, followed by Cameroon, Niger and Chad (UN Office for the Coordination of Humanitarian Affairs – OCHA, 2009). The floods of 26th and 27th August 2011 that devasted most of the city of Ibadan and environs claimed over 100 lives, rendered thousands homeless and destroyed property worth billions of Naira is another consequence of climate change (Adelekan, 2016). Similarly, the floods of July 2011 that swept accross Lagos claimed over twenty lives, rendered many homeless and ravaged other parts of Southwestern Nigeria is another pointer to the eminent threats of Global climate change (Oladele, 2011; Vanguard, 2011; Thisday, 2011; Akinola, 2012,).

Furthermore, Akinola (2012) noted that the National Emergency Management Agency (NEMA) described the floods that emanated from the rainfall in Lagos as the most devastating. NEMA carried out on the spot assessment and noted that the devastation resulting from the down pour, was exacerbated by blockage of water channels and drainages, indiscriminate dumping of refuse and building of houses on the flood plains (Stearns, 2011). Kalu (2011) reported that it rained for 17 hours while the Nigerian Institute of Oceanography and Marine Research also corroborated that the 264 milimeters rainfall recorded in a day was equal to the volume expected for one full month (Akinola, 2012).

Similarly, the National Emergency Management Agency of Nigeria (NEMA) reported that the flood disaster which swept across the country in 2012, a consequence of climate change marked a watershed in the nation's history in disaster management as it was the most devastating in recent times. A total of 363 deaths were recorded, seven million people were affected out of which 2.3 million were displaced while 597, 476 houses were submerged (Ibileke, 2013). NEMA stated further that the total value of the loss across all sectors of economic activities was estimated at $7.3 billion while combined value of the damages and losses was $16.9 billion. Akinsuyi and Sanni (2013) observed further, that apart from Ekiti, Enugu, Katsina Imo, Abia and the Federal Capital Territory (FCT) all other states in Nigeria were likely to suffer from devastating floods in 2013. This was contained in the 2013 Annual Flood Outloook (AFO) for Nigeria presented by the Director General of Nigeria Hydrological Services Agency (NIHS) which was likely to affect 156 Local Governments Areas. Similarly, NEMA warned that 90 local Government Areas in 2013 were likely to be affected by floods following a vulnerability study undertaken by NEMA's Geographic Information System Department based on Nigerian Meteorological Agency (NIMET) rainfall prediction for 2013 (Premium News, 2013). The report warned that more rainfall were likely in 2013 in some parts of the country than 2012 with likely more devastating effects.

Research holds human activities responsible for climate change and its consequences on the human environment (Gasu et al, 2010). Man through his activities in the quest for survival and technological advancement has engaged various environmental planning and developmental strategies which have altered the state of equilibrium in the environment. These activities make use of environmental resources as raw materials and they change the ecosystem which ultimately changes the climatic settings of the environment. Researchers have noted that urban populations in Africa are growing at 3.6 % per year (the highest among world regions) (United Nations, 1994; Cohen, 2004). Urbanisation leads to the erection of structures such as houses and roads as well as the replacement of greenery with concrete, asphalt and steel at the expense of agricultural land and forest. These surfaces are known for their heat conduction, radiation and reflection which increase global temperatures which build up in addition to other human activities which generate carbondioxide and methane which induce climate change (Akinola, 2012).

Global concerns such as environmental protection, climate change, poverty alleviation and sustainable development have been identified by scholars to be the consequence of the growing disparity between population growth (at geometric rate) and resources dvelopment (at arithmetic rate). The quest to develop has increased the tempo and magnitude of degradation of the earth's resources due to the intensified activities of drivers of technological advancement, civilisation and economic development that legitimately demand the mining and burning of fossils fuels, the destruction of forest and agricultural land for highway and industries, and the release of effuellents from industrial and agricultural processes. The uncontrolled and unregulated drives to fufill these developmental agenda have resulted in the release of large quantities of greenhouse gases into the atmosphere. Most researchers have intricately linked environmental degradation with poverty as industrial impacts represent socio economic sponges that soak the welfare of people at local level (Geist and Lambin, 2001; 2002; Seto and Kaufman, 2003; Akinola, 2012).

According to Minter and Wheeler (2009) quoted in Akinola (2012), estimate, shows that the entire African continent was responsible for only 3.7% of the worlds annual CO_2 emmission, compared to China with 21.5%, the United States with 20%, and the European union with 14%, inspite of the fact that African forest absorb 20% of world's carbon. Comparatively, from 1980 to 2005, sub-saharan Africa had 18.5% of the world's population growth and contributed just 2.6% of CO_2 emissions, the United States and Canada had 4% of world's population growth but its share of CO_2 emissions was 13.9% while China had 15.3% of world's population growth and contributed 44.5% of CO_2 emissions, though the contribution of high-income nations is under stated (Satterthwaite, 2009).

Gasu et al. (2010) identified a number of policy responses to combat the looming climate change problem which include: the United Nations Framework Convention on Climate Change, the United Nations Convention to Combat Desertification, Intergovernmental Panel on Climate Change (IPCC, 1988) and Kyoto Protocol (1997) just to mention but a few. Similarly, a number of local content legislations have equally been enacted in Nigeria to combat CC amongst which include; the first legislation on Gas flaring: Petroleum (Drilling and Production) Regulation 1969 Reg. 42. The next important but short-lived legislation was the Associated Gas Re-Injection Decree 1979 promulgated by the military regime of General Olusegun Obasanjo's administration, which specifically required oil companies to: Submit preliminary program for gas re-injection, a period within which to cease gas flaring; and prescribed a penalty for contravention of the Decree. The Associated Gas Re-Injection (Amendment) Decree promulgated by Major General Buhari's administration amended the 1979

Decree to permit companies engaged in the production of oil and gas to continue to flare on the payment of a prescribed fee (Gasu et al., 2010).

Recently, the Nigerian Parliament has been doing a lot to address the negative occurrences on the environment amongst which include the National Climate Commission bill geared towards halting hazards of Gas Flaring on the environmental in the Niger Delta region. There is also the Proposed National Desertification Control Commission Bill intended to deal with the desert encroachment in the north. The National Climate Commission Bill was passed by the National Assembly on the 22 July, 2009, and is still awaiting the signature of the President. The bill is expected to address issues related to strategic planning and coordination of national policies on climate and development (http://allafrica.com/stories/2009; Gasu et al., 2010).

Umejei (2011) observed that the passage of the National Climate Commission bill which Nigeria's Head of State is yet to sign into law, is expected to enable Nigeria access the climate fund of $200 billion that the industrialized nations had agreed to make available annually up to 2020 at the 16th Conference of Parties (COP16) in Cancun, Mexico. In the light of the above, COP17 of the United Nations Framework Convention on CC that held in Durban, South Africa, from November 28 to December 9, 2011, sidelined Nigeria's active participation because of lack of the Climate Change Commission. Other responsibilities of the proposed Commission include; strengthening and coordinating resources, policies and actions on the climate change, such as developing a national strategy for the reduction of Green House Gas emission and advising the Federal Government on climate change policies and priorities in the areas such as renewable energy, technology transfer and transport management. The bill also stipulates that 10% of Ecological Funds and a certain percentage of the Consolidated Revenue Account will be given to the Commission for the discharge of its duties (Umejei, 2011). All these are critical issues that are beyond the capability of a ministry and only a commission can address (Akinola, 2012).

1.2. The study area

The study was undertaken in Ede Region located between latitude 7º 31' and 7 º 55' North and longitude 4 º 15' and 4 º 40' East, Southwestern Nigeria. The area is drained by Shasha and Osun rivers as well as its tributaries and because of the low-lying nature of the area alluvial soils deposits rich in agriculture are predominant. This makes it possible for the digging of shallow wells as well as the possibility for the construction of dams for irrigation. The climate of the area is influenced by two winds (dry and wet), the North East Trade Winds and the South West Trade Winds. The mean annual rainfall recorded from the meteorological station at Osogbo is 1196 mm (Smyth and Montgomery, 1962). The mean annual temperature is 27º C (Balogun and Salami, 1995) and relative humidity of between 67% and 88% (Smyth and Montgomery, 1962). The soils of this area are associated with the Iwo and Egbeda associations. They have been mapped out as soils which have inherent poor drainage because of the presence of 2:1 clay minerals (i.e. montmorillonite) (Okusami, 2011) characterized by tufted grasses almost devoid of trees. The area is located within the tropical rainforest belt but has now been reduced to secondary forest or replaced by perennial or annual crops (Salami et al, 1995). Salami (1999) posited that the long history of agricultural colonization of the area coupled with the increasing population density and increasing pressure on natural resources has led to the modification of the natural vegetation (Mengistu and Salami, 2007).

2. Materials and methods

The materials that were used for this study amongst others include; Satellite images; Land Satellite Thermatic Mapper (Landsat-TM) of 1986 and Landsat Enhanced Thermatic Mapper Plus (Landsat ETM+) of February, 2002 for Ede region, were all obtained from Regional Centre for Training in Aerospace Surveys (RECTAS), OAU Ile-Ife. Topographic maps of 1962 for the region were obtained from Ministry of Lands. Others were; Global Position System (GPS) Gamin 72H, Laptop, scanner, printer, Integrated Land and Water Information System (ILWIS) and ArcGis software.

2.1. Digital image processing

The topographic maps of 1962 were scanned and imported into the ILWIS environment. The maps were then georeferenced, geocoded and a sub-map of the study area extracted, digitized and incorporated into the spatial data base. The satellite images landsat TM of 1986 and ETM+ of 2002 were imported into the computer system, georeferenced, resampled, a sub map created, classified and incorporated into the data base. This was followed by on screen digitization of settlements, roads and other features. Points related features like settlements were incorporated as point features.

In this study land use/land cover classification made use of the following nine classes; dense forest, disturbed/degraded forest, derived savanna/ farmland, forested wetlands, riparian forest, rock outcrops, settlements, water bodies and wetlands (Table 1). The classification made use of training sites and Maximum Likelihood classifier into the land use classes identified in Table 1. Pixels were assigned to a class based on its feature vector, by comparing it to predefined clusters in the feature space. Training sites were selected on the 1986 and the 2002, satellite images and the spectral signatures for each class were extracted using the Image Signature Editor in ILWIS academy. During the process, each selected training site was compared to the signatures and those that resembled the identified classes were assigned to each of the predefined nine classes.

The choice of the Maximum Likelihood classifier was due to the fact that it leads to more accurate results. The change detection technique employed in this study was the post-classification comparison interpretation phase and interpretation of LULC maps according to the method by Hofstee (1997). The classification preceded ground truthing which made use of Global Positioning System (GPS) to ascertain the features identified in the field for easy interpretation of the satellite images. Statistics (Histogram) generated from the classified imageries of 1986 and 2002 were used to compute the basic land use data and quantified the changes and projected into 2018 using the algorithm and the method by Hofstee (1997).

Table1. Description of the land use/land cover classes identified in the study area

Land Use/land Cover Types (LULC)	**Description**
Dense forest	Land area covered with mature trees and other plants growing close together usually with little or no human intervention.
Disturbed/degraded forest	An area of secondary forest cover influence by a lot of human activities such
Derived savanna/farmland	as farming, logging and construction
Forested wetlands	A vegetated area, dominated by grassland sometimes dotted with trees and cultivated land with crops.
Riparian forest	An area covered by water, either standing or free flowing, marsh, swamps, covered by trees and shrubs.
Rock outcrops	Luxuriant vegetation mostly of trees growing along river courses which is typical of tropical rain forest areas.
Settlements	They constitute areas of rocks outcrops on hills and mountains exposed to the surface by the agents of denudation.
Water bodies	These are areas of human habitation cover by buildings for residences, offices, industries and commercial activities.
Wetland	Areas covered by water such as; dams, rivers, streams, ponds and lakes. Areas covered by water either free flowing or standing such as; ponds, rivers, streams, lakes, marsh, mud, swamps and other areas with water table very close to the surface.

Source: Arthur's Field Survey, 2010.

3. Results and discussions

3.1. Land Use/Land Cover Change Detection in Ede Wetland

The results of LULC for the study area in terms of the total area coverage, each land cover type and extent of changes which have occurred, are shown on land use maps and Tables 2 prepared from the satellite images (Figure 1 and Figure 2).

Table 2. Comparison of areas and rates of change of LULC between 1986 and 2002

LULC Types	**1986 LULC Area**		**2002 LULC Area**	
	Ha	**%**	**Ha**	**%**
Dense Forest	6496.41	32.63	5388.26	27.07
Disturbed/Degraded Forest	4177.89	20.99	5140.35	25.82
Derived Savanna/Farmland	2684.04	13.48	3260.87	16.38
Forested Wetlands	1184.72	5.95	1119.06	5.62
Riparian Forest	1363.91	6.85	1594.53	8.01
Rock Outcrops	673.84	3.38	1719.06	8.63
Settlements	530.42	2.66	762.95	3.83
Water Bodies	208.96	1.05	33.38	0.17
Wetlands	2587.93	13.0	889.66	4.47
Total	**19908.12**	**100**	**19908.12**	**100**

Source: Computed from LandSat TM 1986 and LandSat ETM+ 2002

The result shows that before the base year (1986) of the study area, there had been a lot of human interferences as revealed by the detailed results (Table 2). In 1986 dense forest covered 6496.41 ha (32.63%) of the total land use/land cover, disturbed/degraded forest 4177.89 ha (20.99%) of the total land area (Table 2). Furthermore, derived savanna/ farmland made up to 2684.04 ha (13.48%) while wetlands covered 2587.93 ha (13.0%) of the land use/land cover of the study area. Other land use /land cover classes are; riparian forest 6.85%, forested wetlands 5.95%, rock outcrops 3.38%, settlements 2.66% and water bodies 1.05% of the total land area. In 2002, sixteen (16) years from the base year dense forest had reduced to 27.07%, forested wetland also reduced to 5.62%, water bodies to 0.17% and wetlands to 4.47% which were all anticipated considering the increasing pressure on forest and environmental resources from the increasing wave of urbanization.

Similarly, disturbed/degraded forest had increase to 25.82%, while derived savanna/ farmland, rock outcrops, riparian forest and settlements, were increased by; 16.38%, 8.63%, 8.01% and 3.83% of the total land area respectively which were all expected considering the increasing pressure on forest and environmental resources from the increasing population to meet human and developmental needs.

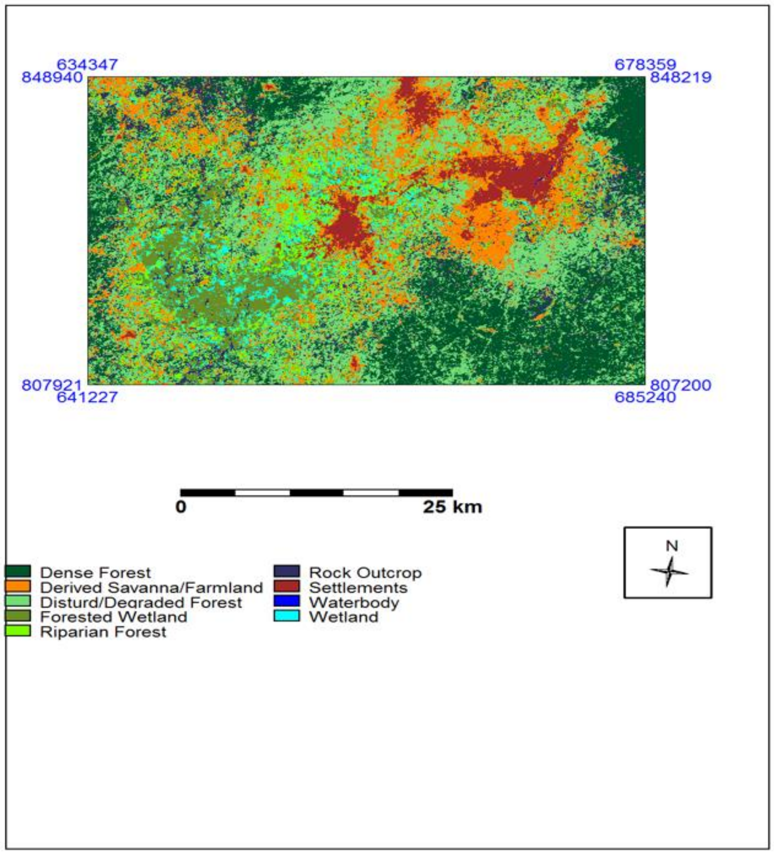

Figure 2. Land use/land cover map of the study area (produced from LandSat satellite Image of 1986)

Table 3 shows further that the pattern of land use change in the study area between 1986 and 2002, had undergone a lot of transformation, a greater part of which could be attributed to human interferences. The result revealed that within the periods mentioned above, there has been a decline in the following land use/land cover activities; water bodies by 84.03%, wetlands by 65.62%, dense forest 17.05%, and forested wetland by 5.54%. On the other hand, rock outcrops, settlements, disturbed/degraded forest, derived savanna/farmland and riparian forest all witnessed a progressive increase in the intensity of land use by; 155.11%, 43.84%, 23.04%, 21.49% and 16.91% respectively. It could be observed that the land use/land cover data for the two years (Figure 1, Figure 2 and Tables 3) indicated both types of changes and conversion and modification which could be attributed to human activities such as agriculture, road construction, housing, governmental policy and deforestation.

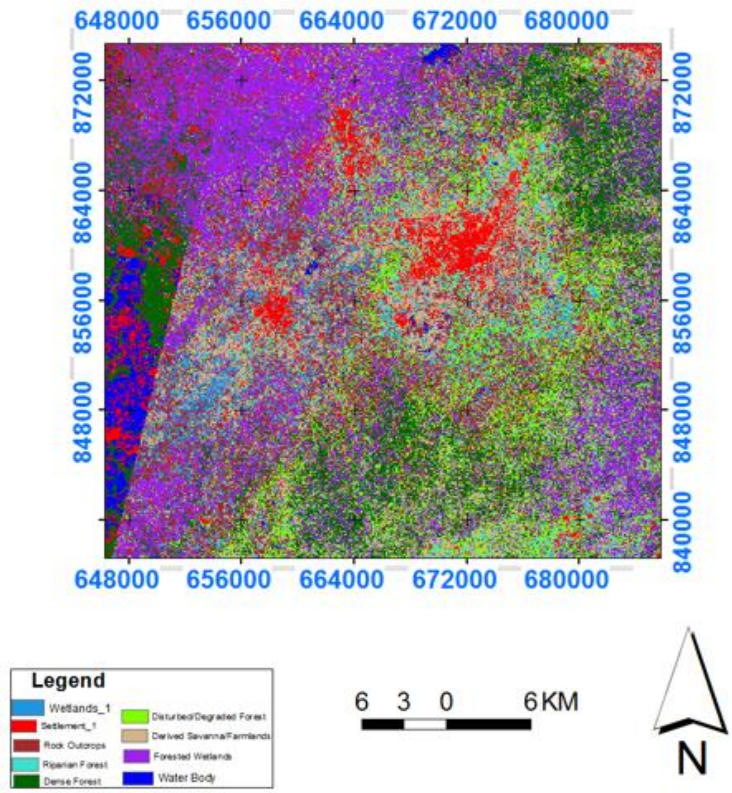

Figure 3. land use/land cover map of the study area (produced from LandSat satellite images of 2002).

Table 3. Comparison of areas and rates of change of LULC between 1986 and 2002

LULC Types	**Change between 1986 and 2002**		**Average Rate of Change between 1986 and 2002**	
	Ha	**%**	**Ha/yr**	**%**
Dense Forest	-1108.15	-17.05	-69.26	-1.07
Disturbed/Degraded Forest	+962.46	+23.04	+60.15	+1.44
Derived Savanna/Farmland	+576.83	+21.49	+36.05	+1.34
Forested Wetlands	-65.66	-5.54	-4.10	-0.35
Riparian Forest	+230.62	+16.91	+14.41	+1.06

Rock Outcrops	+1045.22	+155.11	+65.33	+9.70
Settlements	+232.53	+43.84	+14.53	+2.74
Water Bodies	-175.58	-84.03	-10.97	-5.25
Wetlands	-1698.27	-65.62	-106.14	-4.10
Total	----------	-------	---------	------

Source: Computed from LandSat TM 1986 and LandSat ETM+ 2002.
Note: decrease carries negative sign while increase carries positive sign.

The results show further that, over the sixteen (16) years period water bodies, wetlands, dense forest and forested wetlands were receding at an average rate of change of 5.25%, 4.10%, 1.07% and 0.34% per annum respectively Table 3. Similarly, rock outcrops, settlements, disturbed/degraded forest and derived savanna/farmland expanded their activities over the same period (16years) by 9.70%, 2.70%, 1.44% and 1.34% respectively per annum all due to human interferences. Figure 3 Shows a photograph of a wetland being dredged to give way for urban development while Figure 4: shows a wetland used as a solid waste dump site all in Owode in Ede Region.

Figure 4. A wetland being dredged at Owode, Ede Region

Figure 5. Waste dumped on a wetland in Owode, Ede Region

3.2. Prediction analysis

The exponential growth function is used to predict land use land cover changes in Geographical Information System (GIS) software like ILWIS. In general, the exponential growth function is defined as:

$A_n = A_0 * e^{perc/100*n}$

where:

A_n is the amount after n years

A_0 is the amount in year 0

perc is the growth rate as a percentage per year

n is the number of years

In ILWIS this function looks like: An = A0 * EXP(perc/100*n)

Hence, predicting land use land cover changes from 2002 to 2018, n (number of years) = 16.

- Therefore the expected total dense forest by 2018, ***from table 2, page 11*** will be;

  Ao = 5388.26, n = 16, perc = -1.07

  An = 5388.26*EXP(-1.07/100*16) = 4540.43ha
- Degraded forest in 2018;Ao = 5140.35, n = 16, perc = 1.44

  An= 5140.35*EXP(1.44/100*16) = 6472.23ha

- Derived Savannah/ Farmland in 2018; Ao = 3260.87, n = 16, perc = 1.34

  An = 3260.87*EXP(1.34/100*16) = 4040.53ha
- Forest Wetlands in 2018; Ao = 1119.06, n = 16, perc = -0.35

  An = 1119.06*EXP(-0.35/100*16) = 1058.12ha
- Riparian Forest in 2018; Ao = 1594.53, n = 16, perc = 1.06

  An = 1594.53*EXP(1.06/100*16) = 1889.25ha
- Rock Outcrops in 2018; Ao = 1719.06, n = 16, perc = 9.70

  An =1719.06*EXP(9.70/100*16) = 8115.52ha
- Settlements in 2018; Ao = 762.95, n = 16, perc = 2.74

  An = 762.95*EXP(2.74/100*16) = 1182.74ha
- Water bodies in 2018; Ao = 33.38, n = 16, perc = -5.25

  An = 33.38*EXP(-5.25/100*16) = 14.41ha
- Wetlands in 2018; Ao = 889.66, n= 16, perc = -4.10

  An = 889.66*EXP(-4.10/100*16) = 461.67ha

The results of the exponential prediction between 2002 and 2018 is as presented in table 4.

Table 4. Land Use Land Cover Classification and prediction for the study area

LULC Types	**1986 LULC Area**		**2002 LULC Area**		**2018 LULC Area**	
	Ha	%	Ha	%	Ha	%
Dense Forest	6496.41	32.63	5388.26	27.07	4540.43	16.35
Disturbed Forest	4177.89	20.99	5140.35	25.82	6472.23	23.30
Derived Savannah	2684.04	13.48	3260.87	16.38	4040.53	14.55
Forest Wetlands	1184.72	5.95	1119.06	5.62	1058.12	3.81
Riparian Forest	1363.91	6.85	1594.53	8.01	1889.25	6.80
Rock Outcrops	673.84	3.38	1719.06	8.63	8115.52	29.22
Settlements	530.42	2.66	762.95	3.83	1182.74	4.26
Water bodies	208.96	1.05	33.38	0.17	14.41	0.05
Wetlands	2587.93	13.0	889.66	4.47	461.67	1.66
Total	19908.12	100	19908.12	100	27774.9	100

Source: Computed from LandSat TM 1986 and LandSat ETM+ 2002 and projected to 2018.

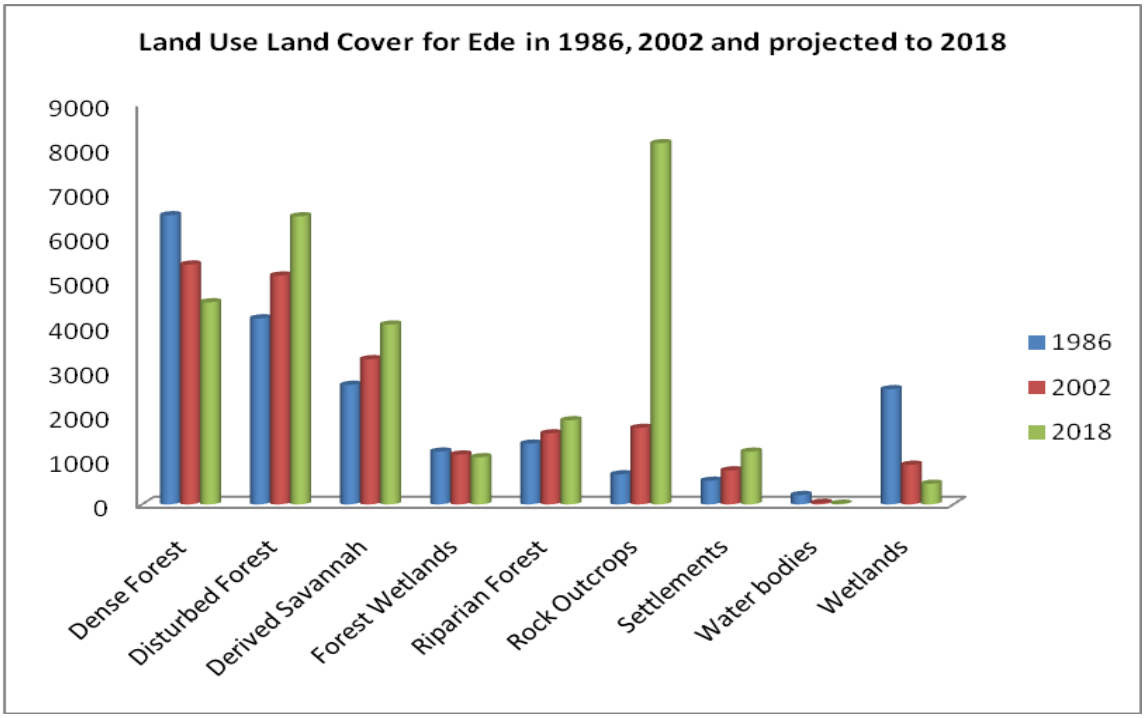

Figure 6. Histogram of land use land cover generated from 1986 and 2002 Landsat satellite images and 2018 projection.

The result (Table: 4) shows that wetlands covered about 2587.93 ha (13.0%) in 1986 and were reduced to 889.66 ha (4.47%) in 2002 but when projected to 2018 it was further reduced to 461.67 ha (1.66%) while dense forests were also reduced from 6496.41 ha (32.63%) in 1986 to 5388.26 ha (27.07%) in 2002 and projected to further reduce to 4540.43 ha (16.35%) in 2018 (Figure 5). Human settlements development a serious agent of land use conversion and change was on a steady increase from 530.42 ha (2.66%) in 1986 to 762.95 ha (3.83%) in 2002 and projected to increase to 1182.74 ha (4.26%) by 2018 (another 16 years period). Similarly, derived savannah and farmland which are the main pressures on natural resources increased significantly which could be attributed to anthropogenic activities of land use conversion such as agriculture, road construction, housing, governmental policy and deforestation which is in tandem with the model by (Salami, 2001; Geist and Lambin, 2002 in Agbola, 2008; Mengistu and Salami 2007).

3.3. The implications of LULC at Ede region on global climate change

Wetlands all over the world are key ecosystems upon which people and biodiversity depend heavily on availability of fresh water and for reducing impacts of extreme weather events. The rising levels of greenhouse gases in the atmosphere due the conversion and degradation of Ede Wetlands are expected to contribute to the global extreme weather conditions like heavy rainfall, prolonged droughts, excessively high and low temperatures, and severe storms. Climate change will also lead to increased numbers of hurricanes and cyclones, floods, drought and desertification. As predicted by the Intergovernmental Panel on Climate Change (IPCC), emission of greenhouse gases will significantly alter the atmospheric temperature between 1.5^{0}C and

4.5^{0}C by the year 2030 (Oseni, 2016). The degradation of wetlands through drainage for agricultural production, urbanisation, fire and over-exploitation is an increasing source of greenhouse gas emission, already estimated to account for over 10% of global greenhouse gas emissions. Our main concern on climate change is the enormous amount of carbon dioxide that are being emitted due to the conversion of Ede wetlands and other wetlands especially, the Southeast Asian peatlands and recently African wetlands into palm oil plantations, mainly due to the rising demand for biofuels, population pressure and other economic drives. Economic drive alone is already exerting a lot of pressure on wetlands and biodiversity.

Considering 1986 as the base year, between 1986 and 2002, Ede wetlands was reduced from 2587.93ha to 889.66ha which emitted about 169.83 tons of carbon dioxide into the global environment and when projected to 2018 Ede wetlands would have been reduced further to 461.67ha contributing about 42.70 tons of carbon dioxide to the global environment (computed based on the consideration that 10% of the drained wetlands, emits 100 tonnes of carbon dioxide per hectare into the atmosphere (Wetlands International, 2007)). Wetlands constitute one of the world's greatest carbon stores; containing a soil of up to 12 meters of organic carbon. The clearing of these wetlands to give way for oil palms to grow and other economic motives will lead to a rapid decomposition of the organic carbon in the soil. Every year, 10% of the drained wetlands, emits 100 tonnes of carbon dioxide per hectare into the atmosphere (Wetlands International, 2007).

4. Conclusion

The study identified anthropogenic factors such as agricultural production, road construction, human settlement development especially housing and deforestation as the key drivers of land use change. Afforestation and preservation of wetland ecosystem, forests and riparian forest through tree planting exercise especially with the bamboo on water sheds, degraded areas, as buffers and the preservation of existing forests and wetlands to serve as a sink to contain the carbon dioxide (CO_2) in the atmosphere could reduce the negative impact of climate change. The Federal Government's ratification of the UN Convention to Combat Desertification (UNCCD, 1994) and its subsequent commitment in 1999 in the tree planting campaign under the theme "a tree for democracy'' is a clear indication that we will survive this environmental drift if it could be sustained. There is also the need to improve on the implementation of international conventions like the Ramsar Convention, the Convention on Biodiversity (CBD), the Convention on Climate Change (CC) and the Convention on International Trade on Endangered Species (CITES) to keep track with the changing global order. The National Climate Commission bill which will enable Nigeria access the climate funds of $200 billion should be implemented. Similarly, Nigeria is yet to establish a clear policy framework on climate change adaptation and that could probably explain why there is no National Adaptation Programmes of Action (NAPA).

Industries need to embark on more voluntary actions to reduce resource use and eliminate waste by making use of cleaner production technologies and develop new environmental friendly energy sources such as biofuels, wind energy, solar energy and energy saving devices. Consequently, there is need for a change in our attitudinal patterns especially as it relates to environment, waste management, resource utilisation as this has been observed at the global level as key drivers of environmental degradation leading to climate change. There is also the need to work in partnership with private companies, local economies, major NGO's, donor countries and foundations such as NCF and international organizations such as, UNESCO, WWF, World Bank, the African Development Bank and the Global Environmental Fund (GEF) on environmental management issues. This can be achieved through training and retraining (capacity building) and economic incentives for local communities to take initiatives on conservation matters such as community forest conservation to enable them earn money from carbon trading. There is also the need to raise awareness among people involved in wetland management through environmental education, advocacy and communication to bring this knowledge to the right people. For if this is not done and should the current rate of wetland loss continue, the consequences of climate change which we are already experiencing especially on the poor and vulnerable are likely to double. Policy measures aimed at tackling these issues must aim at; reducing population growth, poverty, promote economic growth, provide alternative sources of energy to wood, reorient consumption patterns; increase resources use efficiency and structural changes to economies to promote growth. It could be concluded from this study that anthropogenic activities have seriously encroached on the forests, water bodies and wetlands in the study area which have in turn negatively impacted on the global climate, therefore, data collection, site investigations and comprehensive master plans should be undertaken to guide all developmental initiatives.

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