URBANIZATION EFFECTS ON WETLAND ECOSYSTEM IN PARTS OF NIGER STATE, NIGERIA

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ABSTRACT

Wetland ecosystems provide multiple benefits to human settlements; nonetheless, they are seriously threatened due to lack of planning and human activities associated mainly with urban growth. An understanding of their functioning and status is crucial for their protection and conservation. The development and use of coastal areas have increased in recent decades, resulting in significant environmental changes. Thus, these areas have presented different population structures and growth patterns linked to global urbanization trends and demographic changes. The aim of this study is to compare wetland depletion and simulate future changes in parts of Niger State (Chanchaga-Minna, Landzun - Bida and Kontagora) wetlands. Four multi-date Landsat satellite imageries, TM of 1988, 1998, ETM+ 2008 and OLI 2018, were utilized to generate data and was used to analyze and monitor changes that have occurred over time and space. Land-use change modeller was utilized to model the land use and land cover and simulate future urban land use of wetland into 2030. The Normalized Difference Built-up Index (NDBI) was adopted to extract built-up features with indices ranging from -1 to 1. Also, simulation was performed by integrating three drivers (DEM, distance to road and water). Questionnaires were used to examine the potential of effective land-use planning. The results of the classified Landsat images indicate that land use and cover distribution over Landzun - Bida exhibited more concentration of built-up area on the wetland as compared to Chanchaga-Minna and Kontagora. At Landzun-Bida, the built-up areas occupied 12.35km^2, while at Chanchaga - Minna, it occupied 8.2km^2, and in Kontagora, it is 7.8 km^2 between 1988 and 2018. Wetland depletion shows that 3.11km^2 for Bida, 206.24 km^2 for Minna, and 103.53 km^2 for Kontagora are left in 2018, respectively. The simulated results on the wetlands indicate that Minna would have the largest built-up area of 1610.3538km^2 (42.91%), followed by Kontagora 801.1656 (Km^2) 39.59% and Bida 25.6617 (Km^2) (73.67%) in 2030. The implication is that wetland areas would decrease to 4.32km^2 in Minna, 1.16km^2 in Bida and 4.23km^2 in Kontagora by the year 2030. It is paramount to note that human settlements are increasing to wetland areas across the study locations. The conclusion is that spatiotemporal change in wetland land use and the land cover showed that the wetlands changed into different land use and land cover types due to population increase, farmland cultivation and increased built-up areas due to continuous urbanization. Therefore, it is recommended that human activities (both individuals and government) that degrade wetlands should be reduced, restricted or regulated. Also, the focus should be shifted from the immediate benefits derived from conversion to future and sustainable benefits derivable from proper wetland utilizations.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Wetlands are generally flat-floored, relatively shallow, and occupy the lower reaches of watersheds of large rivers, either located near the coast and generally do not have large flood plains (Windmeijer and Andriesse, 2013). They comprise valley bottoms and floodplains, which may be submerged for the greater part of the year? The hydromorphic fringes and contiguous upland slopes contribute water to the valley bottom through runoff and ground water flow. Wetland ecosystems, including rivers, lakes, floodplains and marshes, provide many services that contribute to human well-being and poverty alleviation (Millennium Ecosystem Assessment, 2015). However, they are increasingly subject to intense pressure from multiple human activities such as water diversion, pollution, over-exploitation of natural resources, and reclamation.

As part of a natural ecosystem, wetlands, where they occur in the landscape, are valued for their contribution to ecological balance and biodiversity (Orji, 2014). Also, they are valued for the Numerous goods and functions delivered freely to the ecosystem and human habitats, including flood storage and distribution, retention of sediments and nutrients, aquifer recharge, Water quality improvement, aesthetic and educational benefits, among others (Kindsch er *et al.*, 2015). Unrestrained degradation of wetlands and ecosystems lead to a loss or diminution of some or all of these functions. They also include human-made wetlands such as waste-water treatment ponds and reservoirs (Pepple, 2011). Urban populations and Wetlands have been engaged in a turbulent, somewhat symbiotic marriage since the dawn of civilization. Although wetlands are essential for human well-being, they have been progressively lost and degraded from human activities.

Humans have been using land and its resources for centuries in pursuit of their better lives. The way humans have used land and exploited its resources over time is a serious problem (Cieslewicz, 2002) as it has altered land cover and impacted the functioning of the ecosystem. With the advent of agriculture, modern technology, and the rise of the capitalist economy, the exploitation of land and its resources has increased dramatically. In the last few decades, land-use practices (agriculture, mining, logging, housing and recreation) have become so intensive and predominant that we can see their impacts in forms of uncontrolled development (urbanization and sprawl), deteriorating environmental quality, loss of prime agricultural lands, destruction of wetlands, and loss of fish and wildlife habitats everywhere on the earth. Such impacts have reduced the local capacity of lands to support both ecosystem and human enterprise globally. Therefore, land-use change is no longer a local environmental problem but a global one (Houghton *et al.*, 1994). To address such a problem on a global scale, detailed information on existing land use patterns and sound knowledge about changes in land use through time is important for legislators, planners, and State and local government officials (Anderson, 1976).

Cities are growing faster worldwide, and there will be nearly 2 billion new city residents accounting for around 60 percent of the world's population by 2030, leading to severe damage of natural resources and ecosystems (The Nature Conservancy, 2008). When a city grows, it requires more land and resources to support the growth. This leads to change in land use causing environmental problems such as air and water pollution, loss of open space and biodiversity, heat island effects, etc. Furthermore, because the global human population is growing and rural to urban migration is increasing, the urbanization trend will continue at least for another few decades. This continuation of the urbanisation pattern will increase land and resource consumption and exacerbate the environmental problems which have already posed threats to our planet and cost billions of dollars to our economy. Therefore, planners, governments, planning agencies and others should acknowledge these problems immediately and put environmental perspective into land-use planning and decision-making process effectively and promptly.

Nigeria is endowed with both coastal and inland wetlands, many of which are being threatened by anthropogenic drivers such as land use activities, urbanization, agricultural activities in addition to the emerging threats of climate change (Nwankwoala, 2012; Pepple, 2011; Kindscher *et al.,* 2015; Orji, 2014). Minna, Bida and Kontagora cities, the Niger State economic nerve centres, are lying on a landscape endowed with wetlands and other ecological assets. With rapid urbanization and intense development pressure, some of the fringing wetlands and other land covers have been converted to urban and agricultural landscapes. The study seeks to establish that urbanization in the study area will result in an influx of people from rural areas to urban centers, resulting in the quest for more spaces to provide accommodation or employment for the ever-increasing population. Moreover,lastly, draw attention tothe urgent need to protect and preserve wetlands in the study area. Based on the above background, the study will attempt to evaluate the effects of urbanisation on wetland depletion in Niger State and provide information that will aid policy makers in wetland management.

1.2 Statement of the Research Problem

Man's relationship with his environment has always changed with time, depending on his understanding and knowledge of the physical environment. However, the natural environment is endowed with a variable quantity of resources within the space. Thus, man has come to regard his environment as a way of housing his needs and therefore, he always seeks a way of extracting the resources within it. Sadly, however, this always leads to neglecting the environmental sustenance of several environmental stresses (Ezeaku *et al.*, 2008; Jimoh *et al.,* 2012).

Some parts of Chanchaga, Kontagora and Bida are situated on a wetland ecosystem. As a result of population growth, rural-urban migration, and the failure of successive governments to manage urban growth, these areas have expanded in an unplanned way, leading to the acquisition of more lands in the wetland area. As a result, these wetlands have suffered major encroachment in the recent past, especially in Bida and Chanchaga. A visit to the wetland reveals a lot of new activities, which signify recent massive encroachment. The activities include; residential and commercial buildings as well as car washing bays, among others. There is a significant reduction in the vegetation cover, and the wetlands now experience more visible instances of flooding than before during heavy rains. All these activities put much pressure on the wetland, affect its ecological function and cause degradation.

Niger State wetlands have been variously affected by conversion to developmental uses such as residential and commercial purposes. This is seen in such areas as Chanchaga, Bida and Kontagora. Wetlands along The River Basin and Reclamation Road are mostly devastated and degraded by continuous sand filling and conversion for uses that bring economic activities as against the idea of conserving the wetlands. The institutional/legal frame works such as the Nigerian urban regional planning law as amended, Decree No. 18 of 1999, FEPA, Decree No.86 of 1992, EIA Act of 1992 and NESREA Act no.25, 2007 have not addressed the issue of urbanization and loss of wetland in the Niger state. None of the studies has provided the necessary information for urbanisation and loss of wetland in Niger State. Therefore, there is a need to close this yawning gap which forms the problem of this research. There is also a clear need for further research and improvement on this issue.

Several studies have been published on the effect of urbanization on wetland ecosystem management both locally and in other parts of the world, notable among them in recent times are; Ajibola *et al*. (2012), Pieter *et al*. (2013), Okonkwo *et al.* (2015), and Kometa *et al*, (2018). All these studies did not address the issue of urbanization and loss of wetland in the Niger State. None of the studies has provided the necessary information on the urbanisation effect and the resultant loss of wetland in Niger State. Therefore, there is a need to close this yawning gap which forms the problem of this research.

1.3 Aim and Objectives of the Study

The aim of this study is to evaluate the urbanization effect on the wetland ecosystem in parts of Niger State.

The objectives are to:

i. examine spatial and temporal changes in the areal extent of the existing wetlands in the study area;
ii. analyse the effect of human activities through urbanization on wetland ecosystem in the study area.

iii. simulate the effects of urbanization on wetland ecosystem to the year 2030 in the study area.

iv. examine the potential of land-use planning for an effective wetland ecosystem in the study area.

1.4 Research Questions

The following are the complimentary research questions:

i. To what extent are different wetlands changing within the specified study period?

ii. How does urbanization as a human activity affect the wetland ecosystem in the study areas?

iii. What is the effect of urbanization on the wetland ecosystem in the year 2030?

iv. What are the prospects of land use planning for effective wetland ecosystem management in the study area?

1.5 Scope and limitations of the Study

The study examined the effect of urbanization on the resources of wetland ecosystem, soil, water and biodiversity along the flood plains of Rivers Chanchaga-Minna, Landzun-Bida and Kontagora in Niger State. The study utilized geospatial techniques, reconnaissance surveys and questionnaire administration to assess the effect of Urbanization on the wetland ecosystem in parts of Niger State, Nigeria. In the course of the study, challenges such as difficulty of the terrain which was too marshy and flooded especially during raining season periods were encountered; especially during reconnaissance survey and Questionnaire administration. However, they were all over come and the study moved on smoothly to completion.

1.6 Justification for the Study

Many of the hydrological and water resources problems currently experienced in Nigeria are a result of wetland degradation. The challenges posed by the degradation can better be understood and better appreciated when viewed against the backdrop of the benefits derivable from the wetlands. UNEP (2013) alerts that globally, wetlands have been reduced by 50%. It is estimated that one-third of all endangered species are dependent on wetlands (Asibor, 2009). Nigeria is endowed with abundant surface and groundwater resources, but the water supply situation in the country for various uses remains far below expectation (Nwankwoala, 2011; Uluocha and Okeke, 2014). Aggravating the water management problem in the country is that wetlands, which naturally recharge and protect both the surface and groundwater resources, are being unscrupulously degraded at a rather alarming rate (Uluocha and Okeke, 2014).

Asibor (2009) identified fourteen (14) major wetland belts in Nigeria. However, despite many important wetlands in Nigeria, most of them are undergoing depletion due to population growth and urban land use (Chidi and Ominigbo, 2010). Because of these, the present study investigated the level of degradation of the wetland ecosystem and produced adaptive strategies to aid policy formulation on wetland ecosystem management both in Niger State and Nigeria at large.

1.7 Study Area

1.7.1 Location of the study area

Niger state is situated in the North-central Geo-political zone of Nigeria. It is located approximately between latitudes 8°20′N and 11°30′N, and longitude 3°30′E and 7°20′E (see Figure 1.1). The State is bordered to the North by Zamfara State, to the North-west by

Kebbi State, to the South by Kogi State, to the South-west by Kwara State, while Kaduna State and the Federal Capital Territory border the state to the North-east and South-east respectively. Furthermore, the State shares a common international boundary with the Republic of Benin (Areola *et al.*, 2014).

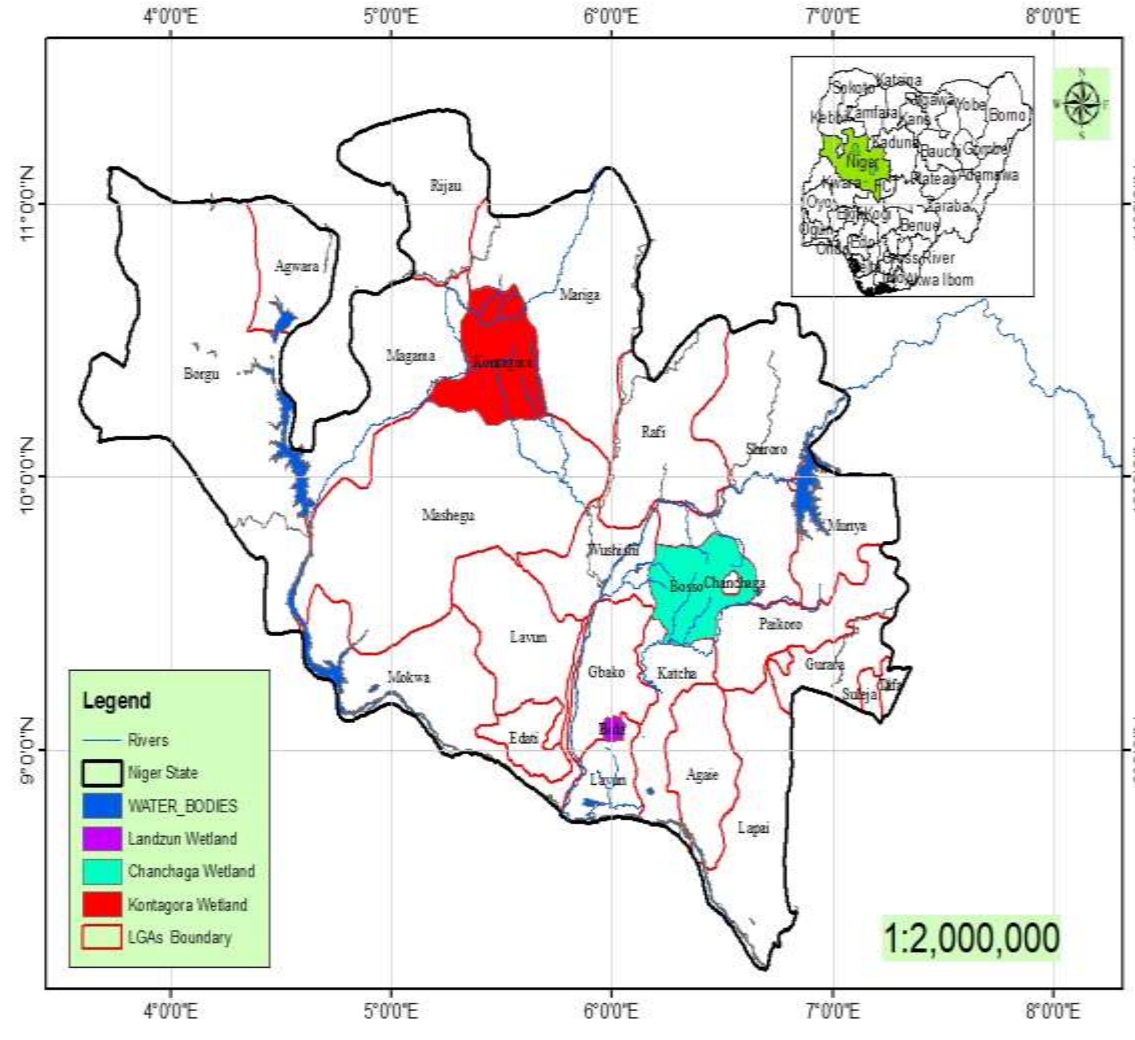


Figure1.1: Study areas (Chanchaga, Bida and Kontagora) Niger State

Source: Department of Geography, FUT Minna.

1.7.2 Size and population

Currently, Niger State covers a total land area of about 76,363 sq. km (about 9 percent of Nigeria's total land area). This makes the state the largest in the country in terms of landmass. An estimated 80% of the state's land area is suitable for agriculture (i.e. arable). The 2006 official census result shows that Niger State has about 3,950,249, comprising 2,032,725 males and 1,917,524 females, representing the proportional share of 51.5% for males, 48.5%, respectively. The state accounts for about 2.82% of the country's population and ranks 18th. As opposed to a national population growth rate of 3.2%, Niger State has an annual growth rate of about 3.4%. (Daramola *et al.*, 2019).

The state has about 26 identifiable native ethnic groups (the major ones being Nupe, Hausa and Gbagyi) and numerous non-native ethnic groups and languages. Administratively, the state comprises of twenty-five (25) local government areas grouped into three (3) agricultural zones which coincide with the senatorial divisions of the state; Zone I (made up of Agaie, Bida,Edati, Gbako, Mokwa, Katcha, Lapai and Lavun LGAs), Zone II (made up of Bosso, Chanchaga, Gurara, Munya, Paikoro, Rafi, Shiroro, Suleja and Tafa LGAs) and Zone III (made up of Agwara, Borgu, Kontagora, Magama, Mariga, Mashegu, Rijau and Wushishi LGAs).

1.7.3 Climate

Niger State experiences a distinct dry season (from October – March) and a wet season (from April – October). Annual rainfall in the state varies from 1,200 mm in the northern part to 1,600 mm in the southern part. The length of the rainy season is 150 days in the Northern parts and210 days in the southern parts of Niger State. Mean maximum temperature remains high throughout the year, hovering about 32°C, particularly between

March and June, while the minimum temperatures usually occur between December and January when most parts of the State come under the influence of the tropical continental air mass blows from the North-East (Harmattan). Generally, the state's climate, soil, and hydrology permit the cultivation of most of Nigeria's staple crops and still allow sufficient opportunities for grazing, fresh water fishing, and forestry development (Daramola *et al.*, 2019).

1.7.4 Geology

Niger State, like other states on the same latitude, is made up primarily of two major rock formations; the sedimentary and basement complex rocks. The sedimentary rocks dominate the southern part of the state and are characterized by sandstones and alluvial deposits, particularly along the Niger valley and in most parts of Borgu, Bida, Agaie, Lapai, Mokwa, Lavun, Edati, Gbako and Wushishi LGAs. This sub-area makes up the extensive flood plains of the River Niger. The basement complex rocks are found primarily in the northern and south-eastern parts of the state. These are mainly characterized by granitic outcrops or in selbergs found in the vast topography of the rolling landscape. Such inselbergs dominate the landscape in Rafi, Shiroro, Chanchaga, Mariga and Gurara LGAs (Nwajide, 2013; Daramola *et al.*, 2019).

1.7.5 Soils and vegetation

Three major soil types can be found in the State. These include the ferruginous tropical soils, hydromorphic soils and ferrosols. The most predominant soil type is the ferruginous tropical soils, basically derived from the Basement Complex Rocks and old sedimentary rocks. Such ferruginous tropical soils are ideal for the cultivation of guinea corn, maize, millet and groundnut. Hydromorphic or waterlogged soils are largely found in the extensive flood plain of the Niger River. The soils are poorly drained and are generally greyish or sometimes whitish due to the high content of silt. Lastly, ferosols developed on sandstone formations and are characteristically red and enriched with a clay subsoil are found within the Niger trough. The Guinea Savannah vegetation covers the entire landscape of the state. Like in other states of similar vegetation, it is characterized by woodlands and tall grasses interspersed with tall, dense species. However, within the Niger trough and flood plains, taller trees and a few oil palm trees occur (Daramola, 2013).

1.7.6 Economy

Generally, agricultural activities form the mainstay of the people's economy, as a large proportion of the population (about 85%) directly or indirectly engages in farming, fishing and cattle rearing. Major crops generally cultivated across the state include *Oryza sativa* (rice), *Dioscoreasp* (yam), *Sorghum Vulgare* (guinea corn), *Zea mays* (maize), *Arachishypogaea* (groundnut), *Vignaunguiculata* (cowpea or beans), *Manihotesculentum* (cassava), *Saccharumofficinamum* (sugar cane), *Cucumismelo* (melon or egusi), *Voandzeiasubterrarean* (Bambara groundnut), *Glycine max* (soy or soya bean), *Ipomoea batatas* (sweet potato) and *Pennisetum typhoides* (millet). Other economic activities in the state (though limited in scale) include pockets of mining, banking, trading, food processing, manufacturing, transportation, local arts and crafts (Daramola *et al.,* 2019).

Bida is a city found in Niger, Nigeria. It is located at 9.08^0 latitudes and 6.01^0 longitudes, situated at elevation 118 meters above sea level. Chanchaga is a Local Government Area in Niger State, Nigeria. Its headquarters is in the state capital of Minna, which occupies much of the Local Government Area. Its geographically located on latitude 9° 32' 0" North, 6° 35' 0" East while Kontagora is located in Nigeria located on the Coordinates: latitude 10°24′N and 5°28′E

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Conceptual and Theoretical Framework

The chapter discusses many concepts and theories related to urbanization and wetland. These concepts and theories will enable us to achieve the aim and objectives set out in this research.

2.1.1 Concept of urbanization

Urbanization is the shift from a rural to an urban society and involves increasing the number of people in the urban area during a particular year (World Bank, 1990). Urbanization is the outcome of social, economic and political developments that lead to urban concentration and growth of large cities, changes in the land use and transformation from rural to metropolitan pattern of organization and governance (World Bank, 1990; Angotti, 1993). In a generic sense, urbanization appeared with the first permanent human settlement 8,000 years ago. Since then, urban development has occurred worldwide, although at different times and in different ways depending on the location.

Urbanization occurs in three broad stages. First, there is an early period when improvement in agriculture lead to population growth and more densely populated settlements (Mackenzie *et al*., 2001). However, urbanization emerged with the industrial revolution, particularly in the developed countries, which became industrialized first. Finally, in the second half of the twentieth century, developing countries were exposed to urbanization after the Second World War. This has intensified over the last 40 years. In 1960, one-third of the world's population lived in the cities. Nowadays, almost half of the planet's population concentrates in the cities, and, by 2030, residents of urban areas will represent more than 60% of the total world population. Forecasts indicate that 2007 will be the turning point. From then on, more people will be living in the cities than in rural areas in the world. Most urban population growth will occur in poorer countries and will involve poor people moving into the cities, looking for opportunities they do not have in rural areas The population of the cities in developing countries has almost doubled since 1960, going from 22 % to 40 % of the total. At the same time, urban population percentage increases in developed countries were only from 61% to 76 % (Mackenz *et al*., 2001).

2.1.2 Concept of sustainable development

The Concept of Sustainable Development is applied to this study. The World Commission propounded the concept of sustainable development on Environment and Development (WCED, 1987). Development involves the purposeful change of inherently complex environmental systems. The natural resources (agricultural products, climatic factors, mineral resources) are consumed and multi-purpose in their social and economic roles. The anthropogenic resources system (infrastructural facilities) is used to improve the people's standard of living.

Consequently, the effects of bad management are often widespread both geographically and socially (Birch, 1973). From the preceding, it is clear that agricultural activities, environmental factors, human needs and infrastructural facilities are independent. Therefore, system analysis or assessment of the total environment and basic socio-amenities should be part of the overall planning process. In making developmental decisions to maintain or improve environmental quality, sustainable provision of basic socio-amenities and food security should be given sufficient weight. This is the basis of sustainable development, an idea first proposed in the eighties by the World Commission on Environment and Development (Railwani and Osayande, 2003).

Again, Sustainable urban development is an offshoot of sustainable development. It thus implies that the present generation embarks on development with the consciousness of the implication of the development efforts. The concept of sustainable development thus incorporates environmental concerns at the inception of development activity (Akinpeju, 2012). Sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their needs (WCED, 1987). The primary objective of sustainable development is to reduce the absolute poverty of the world's poor through providing lasting and secure livelihoods that minimize resource depletion, environmental degradation, cultural disruption and social instability (World Commission on Environment and Development, 1987).

The earth summit (UNCED), which recognized the pressing environment and development problems of the world, and through the adoption of agenda 21, produced a global program of action for sustainable development in the 21st century. Agenda 21 stresses the importance of partnership in improving social, economic and environmental quality in urban areas. It suggests a renewed focus on effective land use planning include adequate environmental infrastructure, water, sanitation, drainage, wetland transportation and solid waste management, in addition to a sound social infrastructure capable of alleviating hunger (Afonja, 1999). Hence, sustainable urban development entails engaging in urban physical development with adequate considerations given to the implication of such development on the ecosystem. Nigeria is blessed with various environmental resources, including wetlands; however, to enjoy better the benefits derived from these resources, there is a need for better management and an effective policy framework.

2.1.3 The concept of wise use in wetland ecosystem

The concept of the wise use of wetlands has been even more of a focal issue to the Ramsar Convention since the Wise Use Working Group began its work in 1988. Much work has subsequently been done throughout the world on the wise use of natural resources. The present publication reflects part of this work which, thanks to several international organizations such as IUCN and the World Conservation Union (and in particular the IUCN Wetlands Program), has permitted a clearer understanding of the sense and strengths of the concept, which will prove helpful in conserving wetlands (Davis, 1993).

According to the guidelines adopted in Montreux 22, November 1990, the wise use of wetlands involves establishing national wetland policies. Whether or not national wetland policies are being prepared, priority actions at a national level and particular wetland sites should be defined. RCB (1990) grouped the principal elements of national wetland policies in the following sections.

i. Improvement of institutional arrangements so that wetland policies can be fully integrated into the planning process; and the establishment of mechanisms and procedures for incorporating this integrated, multi-disciplinary approach into planning and execution of projects concerning wetlands.
ii. Review of existing legislation and government policies (including subsidies and incentives), application of existing legislation and policies, adoption of new ones and use of development funds for wetlands.
iii. Increasing knowledge and awareness of wetlands and their values. Exchange of

information, propagation of their benefits and values (a statement of which is given), review of traditional techniques, and appropriate staff training.

iv. Review of the status of wetlands in the national context, including a compilation of a national inventory and definition of each wetland's particular values and conservation priorities.

v. Address problems at particular wetland sites by integrating environmental considerations into their management, regulating utilization, establishing management plans, designation as appropriate for the Ramsar List, establishing nature reserves, and, if necessary, restoration.

Defining a national wetland policy is often a very long process, and governments may wish to promote priority aspects of the wise use of wetlands before adopting a comprehensive policy. In this context, they need to identify short-term priority actions at the national level and priority actions at specific sites (RCB, 1990; Davis, 1993). The convention on wetlands came into force in Nigeria on 2 February 2001. Nigeria presently has 11 sites designated as wetlands of International Importance, with a surface area of 1,076 728 hectares. In addition, wetlands are also used extensively for recreational aesthetic and educational purposes. Over the world, wetlands are used as recreational sites in various ways – boating, picnics, yachting, fishing festival and boat regatta (Nwankwoala, 2012; Chidi and Erhabor, 2009).

The vast Nigeria wetland ecosystems are in the Niger, Benue and Chad basins. Wetlands represent 2.6% of the country's area of about 923,768km2. The Niger Delta is one of the most important wetlands in Nigeria, the largest in Africa and the third-largest area globally.

Oyebande *et al.* (2003) and Nwankwoala (2012), identify fourteen (14) major wetland belts in Nigeria. These include Sokoto-Rima, Komadugu Yobe, Lake Chad, Upper Niger and

Kainji lake, Middle Niger – Lokoja – Jebba – Lower Kaduna, Lower Benue – Makurdi, Cross River, Lower Niger, Niger Delta, Benin – Owena and Okomu, Lagos Lagoon and Lekki Peninsula, Lower Ogun River, OlogeLagoon, Badagry and Yewa Creeks and the trans boundary wetlands of the Upper Benue. However, despite many important wetlands in Nigeria, most are not well documented and gazetted (Chidi and Ominigbo, 2010). For example, in the entire country, only eleven (11) wetland sites are recognized as Ramsar sites, both inland and coastal (Nwankwoala, 2012).

Table 2.1. Nigeria's 11 Ramsar Sites (1, 076, 728 hectares)

S/N	Site	Date	State (s)	Area (ha)	Coordinate
1	Nguru lake and	02/10/2000	Jigawa and Yobe	58, 100	**100 22′ N**
2	Apoi Creek Forests	30/04/2008	Bayelsa	29, 213	**050 47′ N**
3	Baturiya Wetlands	30/04/2008	Kano	101, 095	**120 31′ N**
4	Dangona Sanctuary Lake	30/04/2008	Yobe	344	**120 48′ N**
5	Foge Islands	30/04/2008	Kebbi and Niger	4, 229	**100 30′ N**
6	Lake Chad Wetland	30/04/2008	Borno	607, 354	**130 04′ N**
7	Lower Kaduna-Middle Niger Floodplain	30/04/2008	Kwara and Niger	229, 054	**080 51′ N** **0050 45′ E**
8	Maladumba Lake	30/04/2008	Bauchi	1, 860	**10024′ N**
9	Oguta Lake	30/04/2008	Imo	572	**05042′ N**
10	Pandam and Wase Lake	30/04/2008	Nasarawa	19, 742	**080 42′ N**
11	Upper Orashi Forests	30/04/2008	Rivers	25, 165	040 53′ N

Source: Nwankwoala, (2012)

Wetlands are important elements of Nigeria's watershed systems (Uluocha and Okeke, 2014; Chidi and Ominigbo, 2010). Many of the hydrological and water resources problems currently experienced in Nigeria result from wetland degradation. The challenges posed by the degradation can better be understood and better appreciated when viewed against the backdrop of the benefits derivable from the wetlands. UNEP (2013) alerts that globally, wetlands have been reduced by 50%. Nwankwoala (2012) estimated that one-third of all endangered species are dependent on wetlands.

Nigeria has surface and groundwater resources, but the water supply situation in the country for various uses remains far below expectation (Nwankwoala, 2011; Uluocha and Okeke, 2014). Aggravating the water management problem in the country is that wetlands, which naturally recharge and protect both the surface and groundwater resources, are being unscrupulously degraded at a rather alarming rate (Uluocha and Okeke, 2014). Nwankwoala (2012) identified fourteen (14) major wetland belts in Nigeria. These include Sokoto-Rima, Komaaugu Yobe, Lake Chad, Upper Niger and Kainji Lake, Middle Niger - Lokoja – Jebba, Lower Kaduna, Lower Benue Makurdi, Cross River, Lower Niger, Niger Delta, Benin- Owena and Okomu - Lagos Lagoon and Lekki Peninsula, Lower Ogun River, Ologe Lagoon, Badagry and Yewa Creeks and the trans boundary wetlands of the Upper Benue. Despite the existence of many important wetlands in Nigeria, most of them are undergoing depletion due to population growth and urban land use (Chidi and Ominigbo, 2010)

2.2 Land Use Change and Urbanization

Land-use change is the change in land cover and land use. Land cover is the physical state of the land surface which includes both natural amenities (crop lands, mountains, vegetation, soil type, biodiversity, water resources) and artificial structures (buildings, pavements) (Meyer, 1995). Change in land cover usually happens in two ways- land cover conversion and land cover modification (Lambin *et al*., 2006). Land cover conversion is a change in the overall classification of land cover through a complete replacement of one type of land cover by another type due to change in urban extent, agricultural expansion or deforestation. Whereas land covers modification is simply a change in the character of land cover without undergoing its overall classification (Lambin *et al.,* 2003). Land use refers to how humans employ and exploit land cover for several purposes (Lambin *et al*., 2006, Meyer, 1995), such as farming, mining, housing, logging, or recreation. Therefore, land-use change is the exploitation of land cover through conversion and modification over time to serve human needs.

2.2.1. Causes of land-use change

There are several causes of land-use change, and identifying them requires understanding the land-use decision-making process influenced by several factors (Lambin *et al.,* 2006). Many researchers and scholars have explained proximate and underlying causes of land-use change to understand the land-use decision-making process. Proximate causes of land-use change involve a direct and immediate physical action on the land cover at local levels such as individual farms, households, or communities (Lambin *et al*., 2006). The underlying causes of land-use change are the fundamental forces that alter one or more proximate causes and operate at regional or even global levels (Lambin *et al*., 2006). Some of the most commonly used fundamental forces are technological, economic, political, institutional, demographic and cultural (Geist *et al*., 2006). In the context of the United States, these underlying causes/fundamental forces are also the causes of urbanization, which is the driver of land-use change.

2.2.2 The connection between land-use change and urbanization

In a more general sense, urbanization is the concentration of population due to movement and redistribution (Geruson and McGrath, 1977). Here movement and redistribution refer to the spatial location and relocation of the human population, resources, and industries in a landscape. Urbanization in the US resulted from two significant economic growth and city growth (Geruson and McGrath, 1977). The growth of the city and economy was attributed to the political independence of the U. S., the rapid expansion of the overall population, development of railroads and rapid spread of automobiles, and the high level of agricultural productivity (Bairoch, 1988).

The process of urbanization results in a dense settlement called an urban area. The conglomeration of urban areas, including cities and their suburbs linked economically and socially, constitutes a metropolitan area or region (Geruson and McGrath, 1977). This definition of the metropolitan area has left out one of the major linkages of the system, an ecological linkage, exploitation of which has created the system itself. (Rostow, 1977) argues that metropolitan area (urban area) results from capitalism, which promotes the diffusion of habitat and activities based on economic functioning and administrative activities. Here diffusion of habitat and activities refers to the consumption of land to locate industrial activities, administrative divisions, new housing units and other infrastructures. He further asserts that metropolitan or urban area reduces the importance of the physical environment in the determination of the system of functional and social relations, abolishes the distinction between rural and urban, and places in the forefront of the space/society dynamic the historical conjuncture of the social relations that constitute its basis (Rostow, 1977). Therefore, one of the goals of this thesis is to make the ecological linkage visible.

Although roughly 5 percent of the people were city dwellers in 1789 when the United States adopted its constitution (Geruson and McGrath, 1977), this number had increased to 6 percent in 1820, and 14 percent in 1850 (Bairoch, 1988) and more than 80 percent of people live in cities now (Frank and Stoops, 2002). Figure 2.1 shows how the U.S. population has become increasingly urban in the last century.

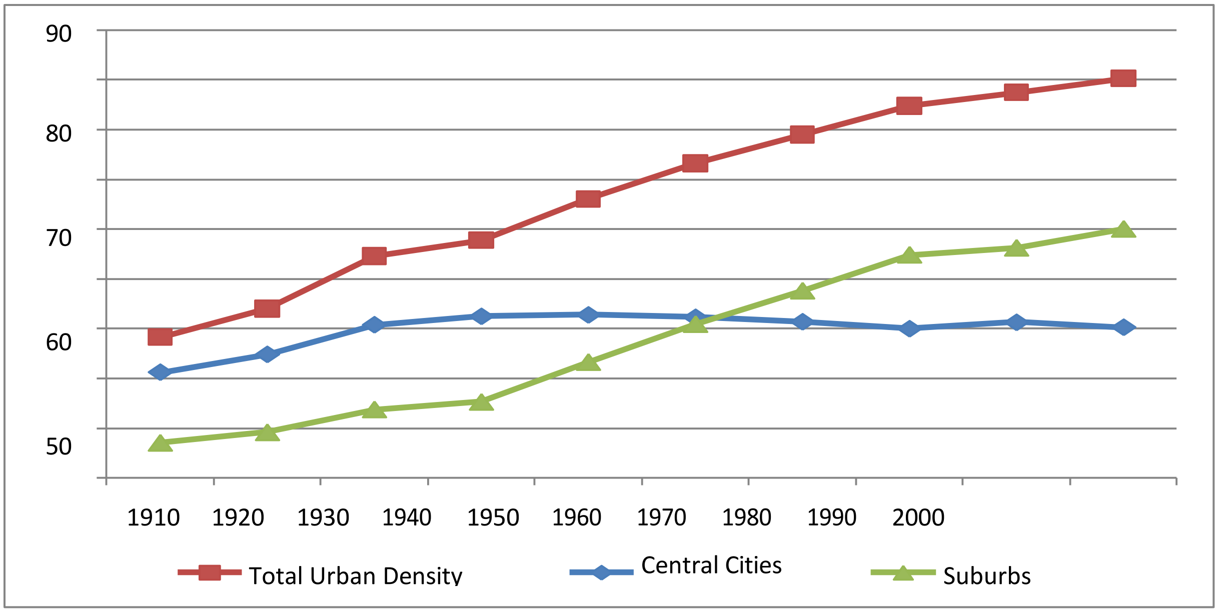


Figure: 2.1 U.S. Urban population (percent) in central cities and suburbs.

Source: U.S. Census Bureau, 2000.

It can be generalized that population density increases with an increase in population. However, this holds only for the confined area. For example, if the total land area of Texas remains the same, but the net migration of people increases, then the overall population density of Texas increases. Nevertheless, if we consider an urban area within Texas, the land area of which is subject to change (usually increase) with time to accommodate the influx of people and businesses, the population density may not necessarily increase, instead of decrease (Anthony, 2004).

Although the overall population density of the U.S. is increasing over the years, the amount of land consumed for urban development has superseded the population density. This is mainly due to the movement of people from the urban core and rural areas to suburbs. In 15 years from 1982 to 1997, urban land in the contiguous U.S., including Hawaii, increased by 39.3%, whereas urban densities decreased by about 13%. In the states with growth management regulations, urban land increased by about 49%, and urban densities decreased by 9.5%. In the states without growth management regulations, urban land increased by about 37%, and urban densities decreased by about 16% (Anthony, 2004).

2.2.3 Ecosystem and urbanization

The Ecological Society of America defines ecology as studying the relationships between living organisms, including humans, and their physical environment. In ecology, physical environment refers to things such as temperature, water, wind and soil (Mackenzie *et al*., 2001). An ecosystem is a particular level of organization in a natural world containing a diverse set of living and non-living components which are self-sustained; regulated by positive and negative feedback loops; and characterized by flows of energy and movement of matters on cyclic pathways (Istock *et al*., 1974). Animal and plant species are the living components of the ecosystem, whereas temperature, air, water, and soil are the non-living components upon which living components depend for survival. These natural components of ecosystems are environmental resources from which an array of benefits can be generated for human consumptions.

2.3 Wetland Ecosystem and its Services

Wetland Ecosystems provide services to living organisms, including humans. Wetland Ecosystem services are the conditions and processes driven by solar energy and generated by a complex of natural biogeochemical cycles such as carbon, nitrogen, sulfur, and life cycles such as bacteria and trees (Daily, 1997).

2.4 Wetland Ecosystem and its Resources

The environmental resources of an ecosystem and their services to humans are infinite and precious. Some of the resources that are fundamental to the natural balance of the ecosystem and, in the meantime, subject to human intrusion are soil, water and biodiversity.

2.4.1 Soil

Daily *et al.* (1997) define soil as a complex and dynamic ecosystem that sustains physical processes and chemical transformations vital to terrestrial life). Soil provides services to all life forms, ranging from microorganisms to plants and animals, including humans. Apart from its ecological or biological services, the importance of soil is deeply rooted in the foundation of human civilization through cultural, immaterial, religious and spiritual belief systems (Winiwarter and Blum, 2006). Montgomery (2007) has linked the importance of soil to the very existence of human civilization as "civilizations do not disappear overnight. They do not choose to fail. More often, they falter and then decline as their soil disappears over generations". He claims that soil is central to the longevity of any civilization (ancient or digital), and therefore we must respect soil as the living foundation for material wealth and treat it as an investment and a valuable inheritance. However, the importance and value of soil are unnoticed and underscored in our society because of it availability and abundance; and more importantly, because soils are always under foot (Warkentin, 2006). Consequently, soils have been used without concern for their loss or degradation, which always carries significant economic and environmental costs (Gregorich *et al*., 2006; Showers, 2006).

2.4.2 Water resources

Water is the most fundamental natural resource which is renewable but finite (United Nations World Water Assessment Programme, 2009; Smith *et al*., 2007). In the U.S. for the year 2005, approximately 410,000 million gallons per day of water was extracted for various uses such as domestic, agriculture, industrial, and recreation. Around 80% of the extracted water came from surface water (Barber, 2009). Sources of surface water are mostly rivers, streams, lakes, and wetlands, including oceans. These water resources are within or adjacent to our land. Therefore, activities on land affect water resources directly or indirectly.

The importance of water is not limited to human consumption, but it is extended to the functioning of a whole planet. Water itself is an ecosystem (aquatic ecosystem) that provides habitats for billions of known and unknown species of animals and plants. From shallow and seasonal wetlands or floodplains to a deep ocean, from a drop of precipitation that infiltrates into the earth surface to a pile of polar ice caps, water cycles continuously into our environment and nurture our planet.

According to the 2007 Gallup Earth Day poll, the majority of people said that they worry "a great deal" about four different water-related problems out of ten environmental problems (Carroll, 2010) (See Table 2.3)

Table 2.3 Public concerns about environmental problems

Environmental Problems	Percentage
Pollution of drinking water	58
Pollution of rivers, lakes, and reservoirs	53
Contamination of soil and water by toxic waste	52
Maintenance of the nation's supply of fresh water for household needs	51
Air pollution	46
Damage to the earth's ozone layer	43
The loss of tropical rain forests	43
The "greenhouse effect or global warming	41
Extinction of plant and animal species	39
Acid rain	25

Source: Carroll, 2010

Scott and Jones (1995) define wetlands as areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters. Similarly, the Section 404 of the Clean Water Act define wetlands as those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions". Wetlands generally include swamps, marshes, bogs, and similar areas (United States Environmental Protection Agency (USEPA, 2010). Wetlands, also known as marshes, swamps, and bogs, are the transitional lands between terrestrial and aquatic systems where the land is covered with shallow water or the water table is at or near the surface. Wetlands are the most ecologically and economically important ecosystems of the nation (Tiner, 2009).

2.4.3 Biodiversity

Generally, biodiversity refers to the richness of animal and plant species native to a particular habitat or ecosystem. Each species present in an ecosystem serves a specific function through the food web and life cycle. A change in species diversity alters the biogeochemical cycles and affects the overall functioning of the system. Therefore, ecosystems' stability, functioning, and sustainability depend on biodiversity (Tilman, 1997).

2.5 Impact of Urbanization on Wetland Ecosystem Resources

Although ecosystem services provide a myriad of functions and services that create value for human users and are central to the continuation of human civilization, humans have obscured the existence and importance of ecosystem services in a hurry to celebrate urban fantasy (Daily, 1997). Vander Ryn and Cowan (2007) expressed the reality of the increasing disconnection of humans with nature as we live in two interpenetrating worlds. The first is the living world (natural world), forged in an evolutionary crucible over four billion years. The second one is the world of roads and cities, farms and artifacts (human designed world) that people have been designing for themselves over the last few millennia.

The growth and prosperity of the human-designed world have come from the expense of the natural world's resources. (Vander Ryn and Cowan, 2007) claim that the designed mess we have made of our neighbourhoods, cities, and ecosystems owes much to the lack of a coherent philosophy, vision, and practice of design that is grounded in a rich understanding of ecology. There is a huge gap between these two worlds- living or natural and human-designed or cultural worlds that have distanced humans from nature. To bridge this gap and link humans with nature, we need ecological thinking in planning practice (Vander Ryn and Cowan, 2007). Vander Ryn and Cowan proposed applying conservation, regeneration, and stewardship strategies into the land-use planning and decision-making process.

2.5.1 Impact of urbanization on soil

Land-use change driven by urbanization has put cities on best soils suited for other uses such as food and fibre, forests and wetlands (Scheyer and Hipple, 2005). New homes, buildings, roads and other structures are built every day. Are these developments guided by sound knowledge about the soil information of the area? Are planners, developers and planning agencies making an intellectual and serious judgment in allocating lands based on soil information for different uses? Moreover, do they care about soil at all? The overall answer to these questions is "NO" because economic benefits guide most developments that have happened and are continuing to happen.

Marcotullio *et al*. (2008) have documented the impact of urbanization on the soil. Urbanization alters the biological, chemical and physical properties of soil and there by degrading its quality, leading to loss of vegetation, poor water infiltration, accumulation of heavy metal, excess water runoff, and soil erosion. The stability of slopes (both natural and artificial) determines the vulnerability of landslides or slope failures. Encroachment of urban land into nearby forested or vegetated areas and the expansion of built-up areas and transportation networks into steeper terrain destabilizing slopes lead to slope failures (Beek *et al*., 2008).

In the U.S., landslides cause $1-2 billion in damages and more than 25 fatalities each year. Urban and recreational developments into hillside areas have put more people and property at risk of landslide hazards (U.S. Geological Survey, 2010). Recently, a portion of Pacific Coast Highway, located in the hilly terrain of Dana Point, California, was closed for about a week due to a possible landslide (The Orange County Register, 2010).

2.5.2 Impact of urbanization on water resources

Population growth, increasing trend of urbanization, and land use and climate change have affected water availability and quality (Smith *et al*., 2007). In many parts of the world, conflicts over water resources have already occurred, and the situation will deteriorate in future (Committee on Water Resources Activities and National Research Council (2004). Although the quality of water has significantly improved in the last few decades due to government regulations and environmental protection programs such as Clean Water Act and the Safe Drinking Water Act, more than one-third of rivers and streams in the U.S. are impaired or polluted, and most of the aquatic ecosystems together with their biota have been lost or diminished to a great number due to non-point source contamination of surface and ground water from agricultural and urban lands (United Nations World Water Assessment Programme, 2009).

Table 2.4. Status of water resources in the United States

Water Body Type	Total Size	Amount Assessed (% of total	Impaired (% of assessed)	Leading Sources of Impairment
Rivers and Streams	3,692,830 Miles	699,946 miles (19%)	269,258 miles (39%)	Agriculture, hydrologic modifications, urban runoff and storm sewers, forestry, municipal point sources, resource extraction
Lakes, reservoirs and Ponds	40,603,893 Acres	17,339,080 acres (43%)	7,702,370 Acres (45%)	Agriculture, hydrologic medications, urban runoff and storm sewers, atmospheric deposition, municipal point sources, land disposal
Coastal resources: Estuaries	87,369 sq. Miles	31,072 sq. miles (36%)	15,676 sq. miles (51%)	Municipal point sources, urban runoff/storm sewers, industrial discharges, atmospheric deposition, agriculture, hydrologic modifications, resource extraction
Coastal Resources: Great Lakes shoreline	5,521 miles	5,066 miles (92%)	3,955 miles (78%)	Contaminated sediments, urban runoff/storm sewers, agriculture, atmospheric deposition, habitat modification, land disposal, septic tanks
Coastal resources: Ocean shoreline waters	58,618 miles	3,221 miles (6%)	434 miles (14%)	Urban runoff/storm sewers, nonpoint sources, land disposal, septic tanks, municipal point sources, industrial discharges,
Wetlands	105,500,00 Acres	8,282,133 acres (8%)	3,442,985 Acres (42%)	Agriculture, construction, hydrologic modifications, urban runoff, silviculture, habitat modifications

Sources: Committee on Water Resources Activities and National Research Council (2004)

At some point in time, the conterminous United States contained more than 220 million acres of wetlands. However, in 2004, the total area of wetlands was reduced to an estimated 107.7 million acres, which accounts for 5.5% of the surface area of the conterminous United States (Dahl, 2006). There was a net gain of 191,750 acres of wetlands between

1998 and 2004. However, this gain was due to the conversion of agricultural lands or the combined effort of conservation measures and restoration of previously impaired wetlands. In the same period, the reports show that there was an estimated loss of 88,960 acres (39% of the loss) due to urban development, 51,440 acres (22 % of the loss) due to rural development, and 18,000 acres (8 % of the loss) due to drainage or filling for silviculture. The rest of the loss, 70,100 ac res (31%) was attributed to deep water habitats (Dahl, 2006).

2.5.3 Impact of urbanization on biodiversity and wetland depletion

Urbanization alters habitat through housing, road construction, pavement, devegetation, plantation of non-native species, land fragmentation. Residential development associated with an expansion of roads and utilities also poses a threat to wildlife through loss, degradation, and habitat fragmentation (Theobald *et al*., 1997). Habitat alteration from urbanization is so drastic and widespread that it results in the endangerment and extinction of species accompanied by long-lasting habitat loss (McKinney, 2002). Apart from reducing the richness of native species, urbanization increases the dominance of nonnative species in the area, thereby causing biological homogenization (Mckinney, 2006).

In collaboration with member natural heritage programs in all 50 states, Nature Serve has maintained a database of around 30,000 imperilled species, i.e. about 15% of the total known species of the U.S. since 1999 (Wilcove and Master, 2005). According to the Nature Serve, Texas ranks second in diversity, third in endemism, fourth in extinctions and eleven thin risk based on the state-wide distribution analyses of 21,395 plant and animal species of the 50 states, including the District of Columbia.

Diversity refers to species richness, endemism refers to unique to a particular state, Extinctions refers to global extinction of species, and Risk refers to the percentage of a state's plant and animal species at risk of extinction (Stein, 2002). Texas ranks first in the diversity of birds and reptiles species, second in the diversity of mammal and plant species and fourth in the diversity of amphibians. Table 2.5 summarised the diversity and risk of species in Texas, United States.

Table 2.5 Diversity and Risk of Species in Texas

Species Categories	Number of Species	Diversity Rank	Risk Rank	Percent at Risk
Vascular Plant	4,509	2	11	9.4
Mammal	159	2	9	10.7
Bird	477	1	6	2.9
Reptile	149	1	9	14.1
Amphibian	71	5	7	21.1
Freshwater Fish	175	12	8	23.4

Source: Stein, 2002

More than 10% of native species in one out of every four states of the U.S. are at risk of extinction (Stein, 2002). Habitat loss, which affects about 85% of the imperilled species, is the leading cause of species endangerment. The spread of non-native species is the second most threat, affecting 49% of the imperilled species (Wilcove *et al.*, 1998, Wilcove and Master, 2005).

Invasion of non-native species, urbanization and agriculture, are the three leading causes of species endangerment due to habitat loss. Urbanization, which endangered 64 species in Florida, 61 in California and 26 in Texas, is the second most threat to species endangerment. In the combined area of Utah, Nevada, and Idaho, where the public owns most land and is unavailable for development, only two (2) species were endangered by urbanization. However, through their construction, maintenance, and use, roads, including highways, have endangered 94 species (Czech *et al*., 2000). Out of the 6,400 imperilled species identified by Nature Serve, 4,173 species were analyzed in the mainland U.S, which showed that approximately 60%was found in one or more of the mainland metropolitan areas, with 31% found exclusively within metropolitan areas. It is a clear demonstration of our traditional reckless planning approach, which ignored the importance of critical environmental habitats and continued to develop. Furthermore, it means the future of these species depends upon the growth patterns of metropolitan areas (Ewing *et al.,* 2005).

2.6 National Policy on Wetland Protection

The content of the National Policy on the Environment is based on realistic planning that balances human needs against the carrying capacity of the environment. The avenue to achieve this is to put in place strategies and policies to ensure that 'environmental concerns are integrated into a major economic decision–making process.' The dominant vibrating principles of the policy include the need of the present generation being met without compromising future generations, the rights of all communities to a clean and healthy environment, and the principle that as much as possible, communities should be involved in making decisions which involve them (FEPA, 1998).

These provisions have responses to all facets of the Nigerian Nation-State. FEPA (1998) outline the ones that do directly impact on wetlands to include: monitor pesticides and agrochemical residue levels in air, soil, water, sediments, flora and fauna and human, document the environmental fate of such chemicals; improved water management technology including the safe disposal of waste, water, waste water- reuse and recycling; establish measures against the trans boundary movement of toxic and hazardous substances within Nigerian Marine and coastal waters; highlight vulnerable species and ecosystems bearing in mind the limited stocks of living and non-living exploitable resources; proscribe all forms of oil and gas exploration and production in estuaries, coastal waters, beaches and resorts, take such measures as will minimize disturbances to wetlands, avian migratory routes, during the process of exploration of oil and gas; Support the role of cognate Non-Governmental Organisation (NGO) professional associations and other civil groups in activities designed to propagate environmental protection, information, techniques and concepts; and honour. The move for conservation was started by the International Union of the Conservation of Wetland Resources (IUCN) in the ’60s.They were concerned with the conservation of wetlands. The COP described the term in 1987 as the ‘sustainable use of wetlands for the benefit of humankind in a way compatible with maintaining the ecosystem's natural properties.

2.7 Nigerian Environment and the Use of Wetland Protection

There are many important wetland belts in Nigeria, the majority of which are found in the Niger, Benue and Chad Basins wetlands, represent 2.6% of the country’s area of about 923,768 km^2. The Niger Delta is one of the most important wetlands in Nigeria, the largest in Africa and third largest in the world.’ Others are found in the axis of the ‘Sokoto-Rima.

Komadugu Yobe, Lake Chad, Upper Niger and Kainji Lake, Middle Niger- Lokoja-Jebba-Lower Kaduna, Lower Benue-Makurdi; Cross River, Lower Niger, Niger Delta, Benin-Owena Lagoon, Badagry and Yewa Creeks and the trans boundary wetlands of the Upper Benue' 3 However, in Nigeria, only eleven wetland sites are recognised as Ramsar sites (Chidi and Erhabor 2009).

The attitude of the government of most nations was a policy not to unduly interfere in environmental issues which they perceived as purely corporate or business affairs as being outside their spheres of influence (Kubasek and Silverman 2002). In Nigeria, the situation was the same. Most literature on environmental protection can identify four decades or timeframes which more or less reflect the historical growth of Nigeria from a colonial to a post-colonial nation (Robert *et al.,* 2016). These periods coincide with the dissemination of scientific knowledge on the environment. More so, environment protection is linked to a people's culture and values. What is predominant in most societies is a quest for a better standard of life. Once this is attained, nations begin to look for the legislative and the executive arms of government to make and execute laws to improve the environment.

There were no laws at the earliest period in Nigeria's history to specifically take care of the specific safeguards needed to protect wetlands. The scope of protection granted by the government was under common law (Akinbola, 2013). The restricted nature of the common law rules were highlighted when applied to the oil industry, especially given the exploitative and non-sustainable nature of oil exploration. Laws that came up at this time dealt with water pollution and air pollution and were also targeted at land, air and water pollution. The environmental laws were mainly geared towards public health, but somehow they offered protection to wetlands by putting a stop to some unconscionable behaviour of people that adversely affects wetlands (Akinbola, 2013).

The attitude of government towards wetlands at the earliest times was to sand fill them and use them for developmental purposes such as construction of roads or cities. Other wetlands still are used by government as dumpsites for wastes. But with growing awareness, it became obvious that wetlands had many useful purposes. The flood absorbing qualities of wetlands was discovered and for the first time, town planning laws made provision for the need for permits for development on wetlands (Robert *et al.*, 2016).

2.8 Laws on Wetland Protection in Nigeria

The protection of the environment is an important link to human existence and health. In this regard, the protection of wetlands is vital as damage to them may reasonably interfere with the enjoyment of life and the economies of the affected communities and the nation. Therefore, we may now examine the various laws that set out to protect wetlands in Nigeria (Agbasi, 2016).

2.8.1 Constitution of the Federal Republic of Nigeria on environmental issues

The law guarantees members of society some rights such as freedom, conscience and association as envisioned in Part IV of the 1999 Constitution of the Federal Republic of Nigeria. The right to a healthy environment belongs to the category of newly recognised rights. In light of this, many world constitutions recognise the right to a healthy environment and have made available processes and procedures for their attainment. It may be necessary to point out that the Nigerian Constitution does not specifically provide reliefs relating to violations of the environment. What are in place are common law reliefs in tort, and these may not be able to cope with the technological advancement of today’s world, especially in complex terrain such as the oil industry. Rather, the constitution made provision in Chapter Two on the fundamental objectives and directive principles of state policy to protect and improve the environment and 'safeguard the water, air and land, forest and wild life of Nigeria.' Section 20 of the fundamental objectives and directive principles of state policy lays out the guidelines to guarantee a safe environment for Nigerians and emphasises the duty of states to protect the environment and continually enhance it (Abdulkadir, 2014).

Nevertheless, these provisions are non- justifiable under section 6(6) (c) of the constitution. They are rightly so seen as policy guidelines. Rather, the justifiable provisions relate to the right to life as guaranteed by section 33 of the 1999 Constitution. 6 Section 46 of the constitution provides relief to the High Court for any person who feels that their fundamental rights under Chapter four of the Constitution have been infringed. Therefore, it becomes necessary to consider whether it is right to include environmental rights in the constitution to ensure a healthy environment (Akinbola and Onifade, 2011).

2.8.2 The harmful waste (special criminal provision)

In the United States, the 1969 oil spill in Santa Barbara, California, was seen as a 'cataclysmic event that held to the celebration of the first Earth Day on April the 22nd, 1970. This gingered lawmakers to set about adopting a tough environmental stance. Similarly, the Koko incidence of 1988 marked a turning point in Nigeria's history of environmental protection. There had been a plethora of legislation before now. However, there were not effective, given that there was no serious commitment to its implementation. At best available threats to sanction offenders were purely administrative, such as seizing of operating licenses of the oil companies in exercise of the powers conferred on the minister under the Petroleum Act. All this dramatically changed in 1988 when an Italian ship with five shipment loads of toxic waste (mostly polychlorobiphenyls (PCBS) berthed in Koko. With the Koko incident, a potentially harmful physical mass was on the ground, and the authorities could not ignore their obligation to protect the public. Nevertheless, it became obvious that there was no legal framework to deal with the amount of toxic waste and chemical menace in question (Akinbola, 2011).

The enactment of the Harmful Waste (Special Criminal Provisions) Decree No.42 of 1988, which is now an Act sought to take advantage of the maximum extent of a regulatory legal framework in consonance with international best practices to initiate action to stem in its infancy, this new unparallel and dominant stress to Nigeria (Akinbola, 2011).

2.8.3 The land use act 1978

Formerly known as Decree No.6 of 1978, the military Government's reaction is to ensure that potential environmental impacts are foreseen at the appropriate stage of project design and addressed before any decision is taken on the project. It is important to protect our fishery, wildlife, creeks, wetlands and other lands, air, medicinal plants and mineral resources from the impact of human activities. Most EIA assessment is carried out by consultants paid for specific projects and need to turn in their reports within a specific time frame. The public is allowed to participate after reports from consultants within a 21day time frame.

The projects related to wetlands are most likely to impact plants, fauna, and fish species directly. Relate to the area of agricultural development, particularly reforestation/ afforestation project, small scale irrigation, small scale aqua culture, saw milling, logging, rubber processing, fish processing, road rehabilitation and other forms of quarrying or mining.

2.9 Regulatory Framework on Wetlands in Nigeria

The National Environmental Standards and Regulations Enforcement Agency (Establishment) Act 2007, the NESREA Act 7 was passed by the Yar'adua administration and repealed the Federal Environmental Protection Agency Act (FEPA Act). The NESREA Act established a corporate entity known as the National Environmental Standards and Regulation Enforcement Agency. The Agency lacks the powers to monitor the oil and gas sector. As such, it cannot oversee the various forms of degradation that may emanate from these sectors. The enforcement powers of the agency are outlined in Part Two of the NESREA Act (Gozie, 2014). .

The agency's objectives are very encompassing and "including coordination and liaison with relevant stakeholders within and outside Nigeria, on matters of enforcement of environmental standards, regulations, rules, laws, policies and guidelines." Therefore, it becomes necessary for the minister of environment to truly demarcate the supervisory powers of the agency by making twenty-four new regulations (Muhammed, 2012). Some of these regulations that may directly or indirectly affect wetland areas include:

National Environmental (Wetlands, River Banks and Lake Shores) Regulation, 2009. Under this regulation, an inventory of wetlands in Nigeria is listed. Data is collected from states and local governments. With the available data, protected areas are declared such that their use is strictly controlled and tourism. River banks and lake shores are also protected.

National Environmental (Watershed, Mountains, Hilly and Catchment Areas) Regulation 2009. This regulation is mostly targeted at landowners or occupiers in watershed, mountainous, hilly or catchment areas. These areas are prone to 'landslides, floods drought, desertification, situation, heavy sediment loads, falling rocks, fires and damage by the wind' and as such, land owners in these areas are encouraged to align their activities to benefit the areas. They have a duty and responsibility to observe the ecological capacity of these areas and, in turn, utilize the best technologies that will ensure optimal soil conservation and avoid significant damage to such a landscape. Typical activities in these areas include livestock grazing, farming and some form of cottage industries (Muhammed, 2012).

2.10 Challenges to the Legal and Regulatory Framework

Good environmental principles should be put into place, which can quickly be activated along alternate remedial lines. Nwosu, 2015 outlined the challenges to the legal framework to include the following:

a. Administrative Bottlenecks

This Leads to Weak Monitoring in EIA Assessments It can be assumed, except the contrary is proved that the authorities in charge of putting in place the administrative structures for monitoring of projects such as the DPR (Directorate of Petroleum Resources) and the Federal Ministry of Environment (FMEev.) are not properly coordinated. As a result, there is no effective screening and processing of the Initial Environmental Examination (EE). It is often done late and sometimes when the projects have commenced without consulting other stakeholders and the public.

b. Unsatisfactory E.I.A Reports

In Nigeria, some establishments are quite advanced, such as in the petrochemical industries. However, the EIA assessors and even some consultants lack the technical know-how to fully document and appraise a certain project. In the developed countries like the United

States, there is a provision made for third party assessors.

Third-party assessors give an independent review of already completed EIA reports to strengthen them further. Nerry Echefu and Akpofure suggest that the staff involved with Environmental Impact Assessment should be well motivated and remunerated. An adequate plan made in insurance according to job hazards and accidents and pension plans should also be put in place.

c. The Constitution:

As far as the Constitution goes, it may be necessary to make the policy guidelines justifiable. However, the notion that making them justifiable will lead to a multiplicity of actions against the government is quite unfounded and derogates from the right of citizens to live in a healthy and vibrant environment.

d. The Land Use Act 1978:

In examining the Land Use Act, Nwosu, 2015 mentioned that rather than enabling individuals to own land, the Act instead enables the upper class in society to own lands that also consist of wetlands. He concludes that ‘these large scale acquisitions have limited farmers rights to land, hindered small scale farming and led to land fragmentation with negative consequences for improved production and sustainable agriculture.

e. Sea Fisheries Decree No. 71 0f 1992:

Despite stringent monitoring paraphernalia, this decree requires further fine-tuning as it does not properly serve as a deterrent to avoid overfishing. Shrimp trawlers land more fish than shrimps due to the wrong interpretation of allowable percentages for permissible fish hauling. The process of registration of fishing trawlers is not comprehensive. It also leaves out rural and urban small-time fishers who operate on wetlands and other inland estuaries with smaller vessels such as canoes, log rafts, and small-sized boats. Their activities are neither documented nor controlled. There is a need for more stringent monitoring and policy implementation.

The Nigerian Constitution also has many fundamental human rights provisions from which the right to a healthy environment can be adduced. Amongst them are such rights as the right to life (section 33), the right to freedom from discrimination (section 42) right to a fair hearing (section 36) and so on.1 Some of them are parallel to the rights found in the African Charter on Human and Peoples Rights 1981. Some of these rights are deemed good enough ground to guarantee citizens right to a healthful environment.

2.11 Benefits of Protecting Wetlands

Traditionally, wetlands have been viewed as places to be avoided and dreaded or as a breeding ground for mosquitoes, as mire for diseases and sources of air pollution. These impressions have been proven to be false as new scientific manners of relating with the environment become available and modern modes of fast and accurate dissemination of information are within the populace's reach (Agbasi and Odiaka 2016). Various roles have been attributed to wetlands that have elevated them to popular venues, not only for recreation but also as economic power houses. Agbasi and Odiaka 2016 enumerated the benefits of wetlands to include the following:

a) Maintaining the earth's ecological balance: Wetlands are very beneficial, and they perform a wide range of functions that are essential for supporting plant and animal life and for maintaining the quality of the environment. These functions include flood control, shoreline stabilization, sediment, balance and preservation of wildlife habitat nutrient and toxicant retention and food chain support. All these functions are interwoven in an intricate balance that is not immediately obvious but has continued to gain prominence and recognition over time.

b) Breeding grounds for migratory birds: Many birds also travel several long distances from developed countries to nest in wetlands in developing countries. In addition, two-thirds of the fish we eat depend on wetlands at some stage in their life cycle, and more than 90% of harvested fish are wetland-dependent species.

c) Protection of Public Health and Safety. In Africa, they are necessary for the survival of various plants and animals and control shoreline erosion. They also improve the quality of drinking water. This is through the protection of 'the wetland water courses, surface and groundwater supplies and water bodies of the town and city from degradation.' In addition, water quality is enhanced by removing sediments, nitrogen, phosphorus and other pollutants from surface water.

d) Wetlands are highly suited for Agriculture: This has to be consistent with best global practices. They provide nutrients for soils by ensuring wetness even during dry seasons by maintaining ecological balance.

2.12 Review of Related Literature

Ajibola *et al*. (2012) used an exploratory approach to study wetlands' effects on Lagos wetlands. The study established that urbanization in the metropolis results from influx from the rural areas, resulting in the quest for more spaces to provide accommodation or employment for the teaming population. Primary causes of wetland loss in Lagos Metropolis are human activities, including incessant sand filling and conversion of wetland environment to economic uses (construction), and perennial flooding that are common and regular occurrences in the metropolis. These resulted in direct habitat loss, suspended solids additions, hydrologic changes, altered water quality, increased runoff volumes, diminished infiltration, reduced stream base flows and groundwater supplies.

Adiege *et al*. (2017) studied the effect of urbanization on wetland and biodiversity in the mangrove forest of Lagos State, Nigeria. Two scenes of Landsat TM (Thematic Mapper) of 1984 and ETM+ (Enhanced Thematic Mapper) of 2006 were used to extract the wetlands, mangroves and water bodies across the area of study. Environment for Visualizing image (ENVI) software was used along with parallelepiped supervised classification in processing the Land-sat images. Results showed that the mangrove wetlands and swamps decreased annually both between 1990 and 2000. It was further seen that the highest decline in the Mangrove was recorded in Epe LGA while that of swamps shows that the highest decline in swamp wetland occurred in Epe and Ibeju-Lekki council area of Lagos State. Results further showed that mangroves widespread in seven council areas around the lagoons in 1990 have dwindled to only four councils in 2000.

Lee *et al.* (2006) studied the impact of urbanization on coastal wetland structure and function in Australia. The study revealed that urbanization is a major cause of the loss of coastal wetlands in Australia. Finding also shows that urbanization exerts significant influences on the structure and function of coastal wetlands, mainly through modifying the hydrological and sedimentation regimes and the dynamics of nutrients and chemical pollutants. By increasing the amount of impervious areas in the catchment, urbanisation results in a replacement of this regime by concentrating rain runoff. Quality of run-off is also modified in urban areas, as loadings of sediment, nutrients and pollutants are increased in urban areas.

Pieter *et al.* (2013) studied urbanization and wetland communities: applying metacommunity theory to understand the local and landscape effects in the USA. The study employed metacommunity theory to evaluate competing explanations for the effects of urbanization, focusing on the relative importance of processes at local (e.g. abiotic and biotic characteristics) and regional (e.g. habitat connectivity and dispersal) scales. Two hundred one wetlands in the Front Range region of Colorado were sampled for over four (4) years. The result shows that wetlands embedded within urban areas exhibited significantly lower taxonomic richness and diversity compared to those in agricultural or grassland areas. Relative to grassland wetlands, urban wetlands supported a 60% lower richness of amphibians and aquatic reptiles and a 33% lower richness of aquatic insects, molluscs and crayfish. These patterns were associated with changes in biotic factors (introduced fishes and bullfrogs), abiotic factors (nutrients, conductivity and vegetation) and landscape characteristics (road density and surrounding wetland area). The use of an information-theoretic approach and structural equation modelling suggested that the effects of urbanization on richness were mainly driven by changes in road density. Analyses of community composition indicated that discrete communities formed along the urban systems gradient, such that actively dispersing predators associated more negatively with urban system relative to herbivores with passive dispersal.

Kometa *et al*. (2018) studied urban development and its implications on wetland ecosystem service in Ndop, Cameroon. The study used structured questionnaire to sample 140 households and Landsat images to complement field observations. With the aid of SPSS (version 21), the correlation between wetland ecosystem services and urban development at 0.05 level of significance was analysed. Results shows a significant negative relationship (r

= -0.551 and -0.682) between urban development and the state of wetlands and their ecosystem services. This was further buttressed by geospatial data which revealed that the Ndop urban space increased from 3.7 km^2 in 1999 to 11.7 km^2 in 2017. The study concluded that the coordination of urban development process through land use planning and zoning is imperative in the face of unabated urban development.

Ayanlade and Proske (2015) carried out an assessment study on wetland degradation and loss of ecosystem services in the Niger Delta, Nigeria. The study examined the spatiotemporal changes in two wetlands in the region by using satellite data from 1984 to 2011 and GIS methods. The results shows that both wetlands have experienced substantial degradation, particularly with respect to the area of forest lost. Although comprehensive environmental protection laws were introduced in 1988, ecosystem services of up to US$65 million in value were lost over the study period. The introduction of new legislation in 2007 was a first step towards a more ‘wise use’ of wetlands in Nigeria.

Wuver and Attuquayefio (2006) studied the impact of human activities on biodiversity conservation in a coastal wetland in Ghana. The study used interviews with a cross-section of the local people, the organisation of durbars, and focus group discussions. The results indicated that, among the various human activities undertaken in the area, fuel wood harvesting, bushfire setting, hunting, and farming had the greatest impact on biodiversity conservation through degradation of the wetland over the years. Furthermore, about 95% of the respondents regarded the “Aboakyer” Festival as a major socio-economic activity in the area that have direct impact on the wetland. The study concluded that little awareness of both “western” and traditional methods of wildlife conservation now exist among the resident in the study area.

Okonkwo *et al.* (2015) assessed the Niger Delta wetland ecosystem: what threatens it and why should we protect it. The study identified tremendous changes in the Niger Delta wetlands due to anthropogenic activities, thus raising awareness on the need for effective monitoring, protection and conservation of the wetland ecosystem. Good knowledge of the services provided by wetland ecosystems is an important key for effective ecosystem management. Findings show that the region is rich in biodiversity of high economic importance to national development and has been under severe threat from human activities, especially pollution. The study concluded that effective monitoring is employed using modern techniques such as GIS and remote sensing to conserve and manage wetland ecosystems.

Mharakurwa (2016) assessed the availability of wetland ecosystem goods and services of the Blesbokspruit wetland in Springs, Gauteng Province. The study used observations, interviews and remote sensing combined with GIS to investigate evidence of change and the possible effects on the Blesbokspruit wetland's natural integrity and availability of ecosystem goods and services in the wetland. Documented spatial changes in land uses were analysed to determine the extent to which land use and land cover changes have affected the natural capital (ecosystem goods and services) for people. In addition, the interaction of local people with the wetland was assessed to establish how they use the wetland as a livelihood support system. The study found that people from the surrounding communities in the upper (Putfontein) and lower catchments (Marievale) are interacting with the wetland in different ways. The provisioning services from the Blesbokspruit wetland to the surrounding communities include water used for domestic and agricultural activities. Both subsistence and commercial farming is taking place along the wetland (crop farming and livestock rearing). The wetland is therefore providing a safety net to disadvantaged households who can supplement their food. The wetland can also regulate climate change (carbon sequestration and flood attenuation) and water quality due to the presence of vegetation. The wetland also supports high biodiversity (flora and fauna) within the Marievale Bird sanctuary. Recreational services of the wetland come from the scenic views noted at both Marievale (picnic spots) and Putfontein (evidenced by children playing and swimming). The integrity of the wetland is primarily threatened by population increase and urbanisation. Remote sensing analyses of land use/land cover patterns between 1998 and 2015 indicate that major changes in the wetland have been due to human encroachment. Subsistence agriculture in the wetland has increased, which fuels damage to the wetland.

Musamba *et al.* (2011) studied the impact of socio-economic activities around Lake Victoria: changes in land use and land use in Musoma Municipality, Tanzania. The study used a structured questionnaire to sample 220 households. Participatory Rural Appraisal (PRA) techniques, participant observation and checklist, were employed in data collection. The land-use types and land-use changes were examined through the analysis of satellite imageries. This was attained by making use of ArcGIS10 and ERDAS Imagine 9.1. The socio-economic data were analysed using Statistical Package for Social Sciences (SPSS). The land use/cover identified was Lake Victoria, CBD, infrastructures, Kitaji swamp, fishing areas, settlement, farms, industrial areas, tarmac roads, and recreational areas. Findings show that there is a strong relationship (r =91.3%; p=0.001) between anthropogenic activities and land use type/ changes. These activities have caused the deterioration of the wetland area and its values at the average rate of 6.5 hayr-1, which was observed from2001 to 2008. Lack of awareness on the role of wetlands was found to impede the participation of local people in Lake Victoria conservation. The study concluded that natural resources management (including wetlands) should be integrated into the curriculum of all education levels to foster awareness-raising campaigns on the role of wetland benefits to local people's livelihoods.

Nguh and Kimengsi (2016) studied land-use dynamics and their implications on wetland management in Bamenda. The study utilised land use maps for two periods, 1984 and 2014, and semi-structured questionnaires. The result shows that a positive relationship (0.5) was observed for land-use change and wetland degradation. Furthermore, the results from land use analysis showed that between 1984 and 2014, significant changes were observed for residential land use, which increased in surface area from 42% as of 1984 to 53% in 2014. In addition, agricultural land use increased from 11% to 34%. Conversely, the surface area covered by wetlands reduced from 27% in 1984 to 6% in 2014. The study concluded that in the face of further wetland degradation, the current trend of land use dynamics could be checked by applying zoning laws to control the changes witnessed in the land uses (residential and agricultural land uses).

Lizias and Felix (2013) studied wetlands and urban growth in Bindura, Zimbabwe. Data was collected through a self-administered questionnaire with EMA officials being the survey respondents, and a reconnaissance survey was also carried out on four wetland sites within the study area. The study revealed that housing construction depleted the water table and gave rise to underground water pollution. Other findings include habitat loss, water diversion structures, impairment of wetlands, among others. The study concluded that wetlands should be utilized so that it would not affect the ecological functions, such as creating parks and golf courses.

Mironga (2005) examined farmers' knowledge of the environmental effect of agricultural expansion to wetlands. The study discovered a lack of knowledge of the characteristics of farming activities and farmers' attitudes to planning mechanisms to support wetland protection in the area. The majority of farmers ignored the effect of agriculture on wetlands. Those who occupied wetland areas practiced intensive agriculture and were ignorant of this effect on water quality, soil, and landscape. The study concluded a need to build a conservation ethic among wetland users by educating them to sustainably utilize wetland resources and training them to practice sustainable agriculture.

Zhou *et al*. (2017) studied the effects of the land-use change on ecosystem service value in Daqing. The effect of the land-use change on the ecosystem value between 1995 and 2015 was analysed based on the Chinese territorial ecosystem's unit area ecosystem service value from Mr. XieGaodi and the ecosystem service value calculation formula from Costanza. Results showed that the ecosystem service value of Daqing decreased from US $4343.1559m in 1995 to the US $3824.327m in 2015, with the ecological value of US $518.8289 m decreased during the past 20 years. The study further discovered that wetland and water bodies were the two main land utilization types with the highest contribution to ecosystem service value. As a result, ecosystem services value per capita decreased to 23.52%. Furthermore, the sensitivity coefficient of eco-service values of all land utilisation types to their value coefficients was less than 1 in the Daqing area. The sensitivity coefficients followed that wetland > water body > woodland > unutilized land > pasture land> cultivated land in 2015, which shows that the changes of the land utilization were lack of flexibility to the changes of the ecosystem service value.

Ohwo and Abotutu (2015) reviewed the environmental impact of urbanization in Nigeria. Findings revealed that there are several pieces of evidence of the environmental impact of urbanization in Nigeria. The linkages between the urbanization process and the environment were profound. The major components of the environment air, water and land are adversely affected by the daily anthropogenic activities of urban residence and exploiting the natural resource base. The study observed that the goal of ensuring environmental sustainability is greatly threatened by urbanization, which has created several serious environmental problems, such as pollution, deforestation and wetland destruction, erosion and flooding, urban sprawl, slum and squatter settlements, heat island and aesthetic degradation that have had negative impacts on man and other living organisms in the environment.

2.13 Summary of Review of Similar Studies

The overall lesson drawn from this review is that most of the studies conducted in different regions of the world have shown that urbanization affects the wetland ecosystem in various ways. The magnitude of changes varies from one location to another. Studies have shown that increased urbanization is responsible for reducing wetland quality in different parts of the world. Therefore, there is the need for more research in this area to find a solution to the possible impact of urbanization on the wetland ecosystem in the study area.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Types and Sources of Data used

The two main data sources utilized for this study are: primary and secondary

3.1.1 Primarydata

Primary data was collected during the research, especially through surveys and direct communication with respondents. The methods used include;

3.1.1.1 Interview schedules - The interviewee was asked different questions depending on the information needed interactively.

3.1.1.2 Focus group discussion –This was carried out with relevant authorities in land use planning and Wetland Management in the study area.

3.1.1.3 Questionnaires– researcher assisted questionnaire was used to include the high illiteracy levels of the sample population. The questionnaire contained several questions on wetland management and was administered to the selected households to explain the purpose of the study and the meaning of the questions if they are not clear to the respondents.

3.1.1.4 Observation – this was used to measure the overt behaviour of persons and the environment andcovered the subject observed, the length of observation, the behaviourobserved,and recording of observed changes.

3.1.1.5 Photography – was used to show the area of the study clearly and capture the anthropogenic activities taking place and their contribution to the reduction of the wetland area.

3.1.2 Secondary data

(i) Landsat imageries of the study areas in Niger State for 1988 1998, 2008, 2018 were collected and utilized for this study. The imageries were sourced from Global Land Cover Facility (GLCF) and National Space Research and Development Agency (NASRDA), Abuja, Nigeria.

The data used for this study was sourced from a time series of Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper plus with Thermal Infrared Sensor (TIRS) images. This was used to derive land use and land cover maps of the study areas. The spectral resolution of Landsat TM and ETM+ (30 m) data makes it very useful for land-use change and land cover classification, and general mapping.

The dataset includes a notable period of four decades 1988, 1998, 2008 and 2018. The raw satellite data were obtained from the archives of the United States Geological Survey and Earth Explorer. The maps were projected using Universal Transverse Mercator (UTM) and datum WGS 84 of zone 32.

3.2 Geo- Referencing Properties of the Images

The Geo-referencing properties of 1988, 1998, 2008 and 2018are made up of universal Transverse Mercator (UTM) projection, and datum WGS 84, zone 32

3.2.1 Software used

Software used in this research work include

- IDRIS Terrset: This was used to develop land-use and land cover prediction classes for the study areas.

- ArcGIS 10.3: This was used in developing, display and processing the location maps.

- Microsoft Word Office 2013: was used basically for the presentation of the research work.

- Microsoft Excel was used to produce the Bar charts and graphs and convert the coordinates into x and y degrees of decimals.

3.3. Method of Data Analysis

3.3.1. Objective one examines the spatial and temporal changes in the areal extent of the different wetlands in the study area. This was achieved using the Landsat satellite imageries of 1988, 1998, 2008, 2018 using a Maximum likelihood classification scheme with five (5) land use/land cover classes (wetland, water body, built-up, agriculture and vegetation).Calculate the area in square kilometres of the resulting land use/land cover types for each study year and compare the results.

The comparison of the land cover statistics assisted in identifying the percentage change, trend and rate of change through the study period. In achieving this, the first task was to develop a table showing the area in hectare and the percentage change from each year measured against each land cover type.

Percentage change was calculated by the preceding year's value and multiplied by 100 to determine the changing trend. The equation is given as:

$$\text{(Trend)Percentage change} = \frac{\text{Observed change X 100}}{\text{Value of the preceding year}} \qquad (1)$$

In obtaining the rate of change, the percentage change is divided by 100, and multiplied by the total number of years 1988– 2018 (30 years) of the study.

3.3.2 Objective two analyzed the effect of human activities through urbanization on wetland ecosystems in the study area. This was achieved using the Normalised Difference Built-up Index (NDBI) to extract built-up features and have indices ranging from -1 to 1.

The equation is given as:

$$NDBI = (SWIR - NIR)/(SWIR + NIR) \quad (2)$$

Where;

SWIR= Shortwave Infrared

NIR=Near-Infrared

3.3.3 Objective three simulation of the effect of urbanization on wetland ecosystem to the year 2030 in the study area. The Markov-Cellular Automata (CA) Model was used to project land use and land cover evolution from GIS/remotely sensed data to a transition probabilities matrix and a transition area matrix and in considering spatial interactions explicitly through the definition of the transition rules. A MARKOV and CA_MARKOV function available in Idrisi Selva software was used.

The M-CA based model was processed for three dates to produce a transition probabilities matrix which determines the likelihood that a cell or pixel will move from a land-use category or class to every other category from date 1 to date 2. This matrix results from cross-tabulation of the two images adjusted by the proportional error and is translated in a set of probability images, one for each land-use class. A transition area matrix records the number of cells or pixels that are expected to change from each land-use class to each other land-use class over the next period.

This matrix is produced by multiplication of each column in the transition probability matrix by the number of cells corresponding to land use in the later image. This Markovian model also outputs a set of conditional probability images. The images report the probability that each land cover type would be found at each location in the future phase, as a projection from the latter of the two land-use/land cover images was taken from the transition probability matrix,.

Projection of land use and land cover is carried out to2030 using a short and long trajectory (1988 - 1998, 1998-2008, and 2008-2018). Both trajectories are taken into consideration to evaluate the influence of the length of the temporal trajectory in modelling plausible land use and land cover future states. In the long-time trajectory, the 2030 transition probabilities matrix was built from the land-use/land-cover images of 2008 and 2018.

The state transition area matrix and state transition probability matrix are created according to land use maps in 1988 and 2008, which can be obtained by running the CA-Markov model in IDRISI software based on the suitability atlas that has already been created.

The predictive map for 2018 was obtained with a 5×5 contiguity filter, whose running cycle is 20 years. The CROSSTAB module in IDRISI was used to analyze the predictive results of 2018 for Bida, Kontagora and Chanchaga by overlaying the land use map of 2018 that is truly classified.

Usually, the Kappa values range from 0 to 1. Values of 0.61 – 0.80 means substantial, while 0.81–1 means almost perfect (Liping *et al.*, 2018). Therefore, where the Kappa index is less than or equal to 0.4, the land uses greatly with poor consistency between the two images. However, if the Kappa index is 0.4 – 0.75, there are general consistencies and obvious changes between the two images. Otherwise, there is high consistency between the two images (Yousheng *et al.*, 2011).

3.3.4Objective four examines the potential of land use planning for effective wetland ecosystem management in the study areas. Focus group discussion and questionnaire was used. A stratified random sampling approach was adopted in the administration of questionnaires. This entails stratifying the target population according to the location, occupation and proximity or defined buffer distance from the wetland. Descriptive statistics were used for the analysis.

A total of three hundred and fifty (350) questionnaires was administered in three wetland areas that constitute the study area. A total of 335, representing 95.7%, were returned. Bida has the highest response percentage (96.7%), while Chanchaga and Kontagora recorded 96% and 94% responses, respectively.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Classification of Land use/Land cover Dynamics (1988, 1998, 2008 and 2018)

The classification results for the LULC dynamics are presented using tables, charts and figures for illustration and interpretation of all land use/land cover classes in the four epochs 1988, 1998, 2008 and 2018 for the various study areas to quantify the changes that have taken place over time and space. Each study area was explained based on sub-themes such as the general land area and the 500-metre buffer in Kontagora and Bida, then a 1km buffer around river Chanchaga.

4.1.1 Analysis of land use/land cover classification for Kontagora

(a) 1988 Satellite imagery LULC classification for Kontagora

The land use/ land cover map gives an account of the spatial distribution and areal extent of various categories of land use/land cover over the study area. Figure 4.1 presents the classified land use/land cover map of the study area for the year 1988. The map portrays five (5) land use/land covers; built-ups, wetlands, farmland, vegetation and water bodies. The areal extent of these classes reveal that the dominant class is farmland which covers 749.2374 Km2 (36.41%), followed by vegetation with 633.2157 Km2 (30.77%), wetland covers 605.5362Km2 (29.42%. This is seen scattered mostly at the eastern section of the map and the south-west, while Built-up covers 37.2438 Km2 (1.81%) and water bodies with 32.769 Km2 representing 1.59% of the total area as the less dominant classes.

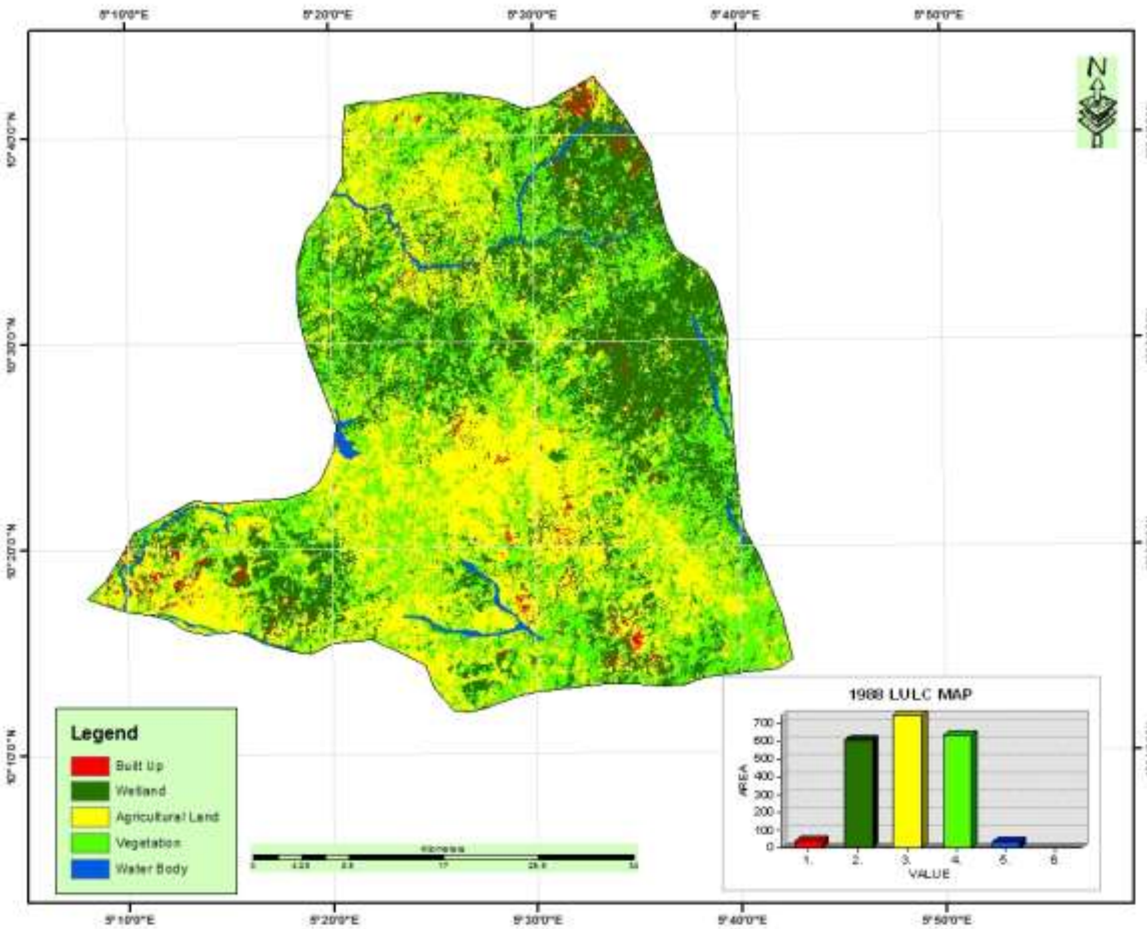


Figure 4.1 Kontagora 1988 land use/land cover distribution map generated from LandSat 4 TM

Source: Author’s Analysis, 2018.

(b) Analysis of Land use/land cover Classification of 1998 Satellite Imagery for Kontagora

The land-use change chart and map of Kontagora in 1998 (Figure 4.2) reveals that the farmland area continues to increase to 909.7578 square kilometres (44.19%). Most of the farmland lands were located in the study area's northern, southeastern and western parts.

The large proportion of cultivated land area indicates that most marginal dry and wetlands have been converted to farmlands. This is followed by wetland 631.0233 square kilometres (30.65%), vegetation was 415.8297 square kilometres (20.20%), while built-up and water body represent 52.2225 square kilometres (2.53%), 49.653 square kilometres (2.41%), respectively.

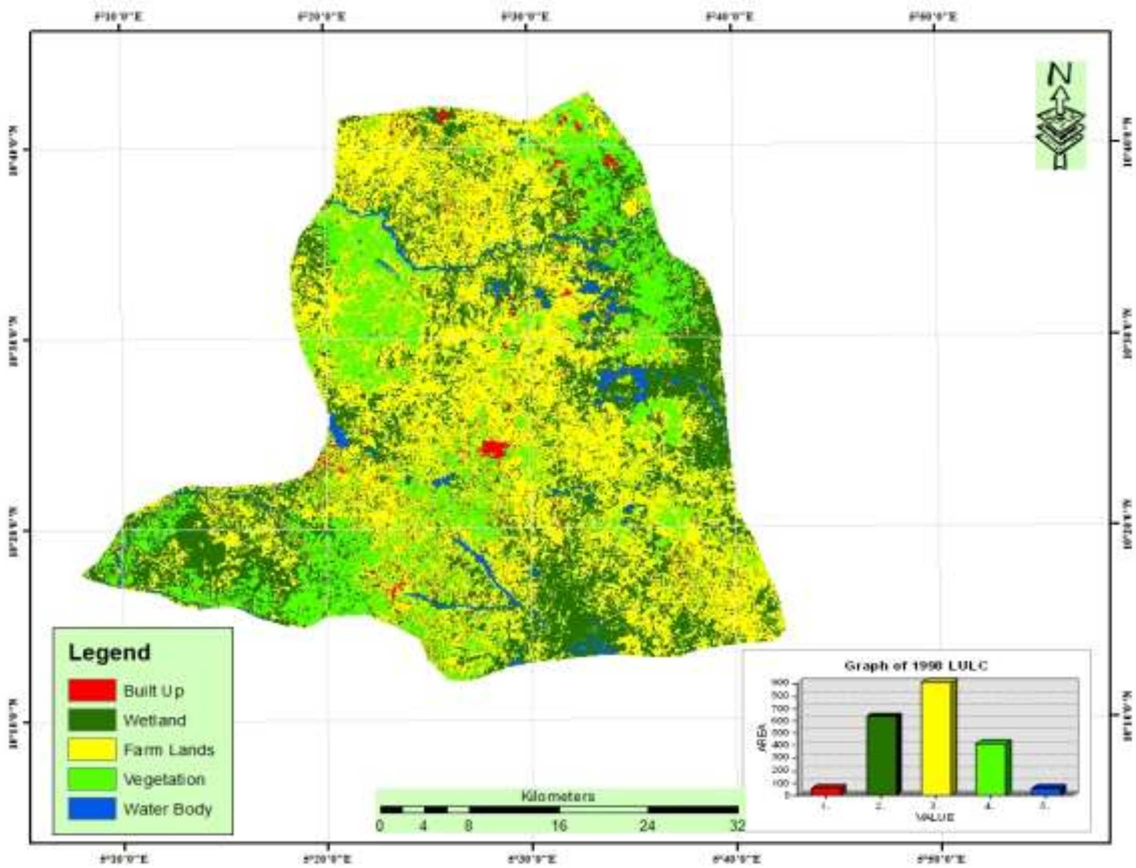


Figure 4.2 Kontagora 1998 land use/land cover distribution map generated from LandSat 4 TM
Source: Author's Analysis, 2018.

(c) Analysis of land use/land cover classification of 2008 satellite imagery for Kontagora

Figure 4.2 shows the LULC of the study area in 2008, indicating that farmland reduced to 718.8597 Km2 (34.92%). This can be attributed to an increase in built-up and vegetation cover while on the other hand, the vegetation becomes the most dominant land cover type, which covers an area of 727.8444 Km2 (35.36%). This is followed by wetland which decreases from 631.0233 square kilometres (30.65%) in 1998 to331.6329 Km2 (16.11%); this reduction can be attributed to the encroachment of other LULC classes on wetland areas.

Also, built-up areas have increased continuously within the tenth year from 52.2225 square kilometres (2.53%) in 1998 to 268.3269 Km2 (13.03%). This sharp increase can be attributed to the continuous influx of people due to the relative security and improved socio-economic development in the area. Finally, water bodies decrease from 49.653 square kilometres (2.41%) in 1998 to 11.8746Km2 (0.58%).

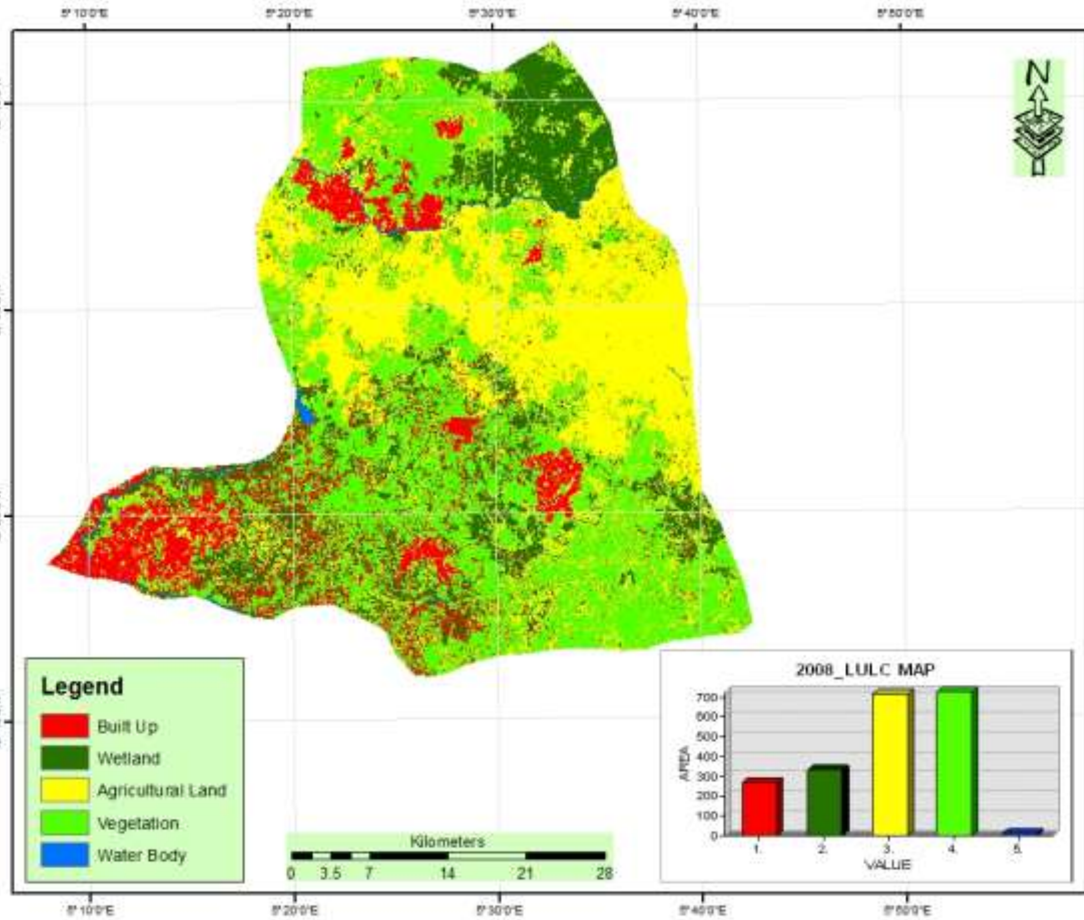


Figure 4.3: Kontagora 2008 land use/land cover distribution map generated from ETM+

Source: Author's Analysis, 2018.

(d) Analysis of land use/land cover Classification of 2018 Satellite Imagery for Kontagora

Figure 4.4 reveals the land use and land cover (LULC) map for the year 2018, and it shows that built up and farmland is on the increase while the other LULC types continue to decrease due to continuous anthropogenic activities in the study area. The areal extent for each LULC indicates that farmland area is the most dominant land use and the land cover type, covering an area of 775.7793Km^2 (37.69%) in 2018. The increase in farmland can be attributed to the present government commitment to improving agricultural productivity by providing farm inputs and loans to farmers through various initiatives such as the anchor borrowers programme of the Central Bank of Nigeria. This is followed by vegetation which occupies an area of 612.09Km^2 (29.74%), while built-up also increased from 37.2438 Km^2 (1.81%) in 1988 to 489.114Km^2 (23.76%) in 2018, an increase of (21.95%) which ultimately result in the conversion of wetland areas into farmland as well as built-up areas due to the low plain which reduces the cost of building in such areas. Also, wetland areas reduced tremendously from 605.5362 Km^2 (29.42%) in 1988 to 146.5695 Km^2 (7.12%) in 2018, thus representing 22.3%. Finally, water bodies covered 34.8849 Km2 (1.69%) of the total land area.

The land use and land cover map of figure 4.4 reveal a clear pattern of increased urban expansion from the urban centre to adjoining non-built up areas along major transportation routes. The highest rate of urban growth is observed during the third period of urbanization (2008 to 2018), in which the built-up area increased more than twice 220.79Km^2 (10.73%) within 10 years, as shown in Table 4.1. This is followed by14.98Km^2(0.73%) between the 1988 to 1998 period of urbanization, respectively. This indicates rapid urbanization in the study area between 2008and 2018 compared to 1988 and 1998. It could result from improved socio-economy activities due to increased population in the area since it is one of the major urban centres in Niger. This is in line with the work of (Ajibola *et al.*, 2012b), who carry out similar work effects of urbanization on Lagos wetlands and found out that urbanization had resulted in direct habitat loss, suspended solids additions, hydrologic changes, altered water quality, increase runoff volumes, diminished infiltration; reduce stream base flows and groundwater supplies, prolonging dry periods to mention just a few

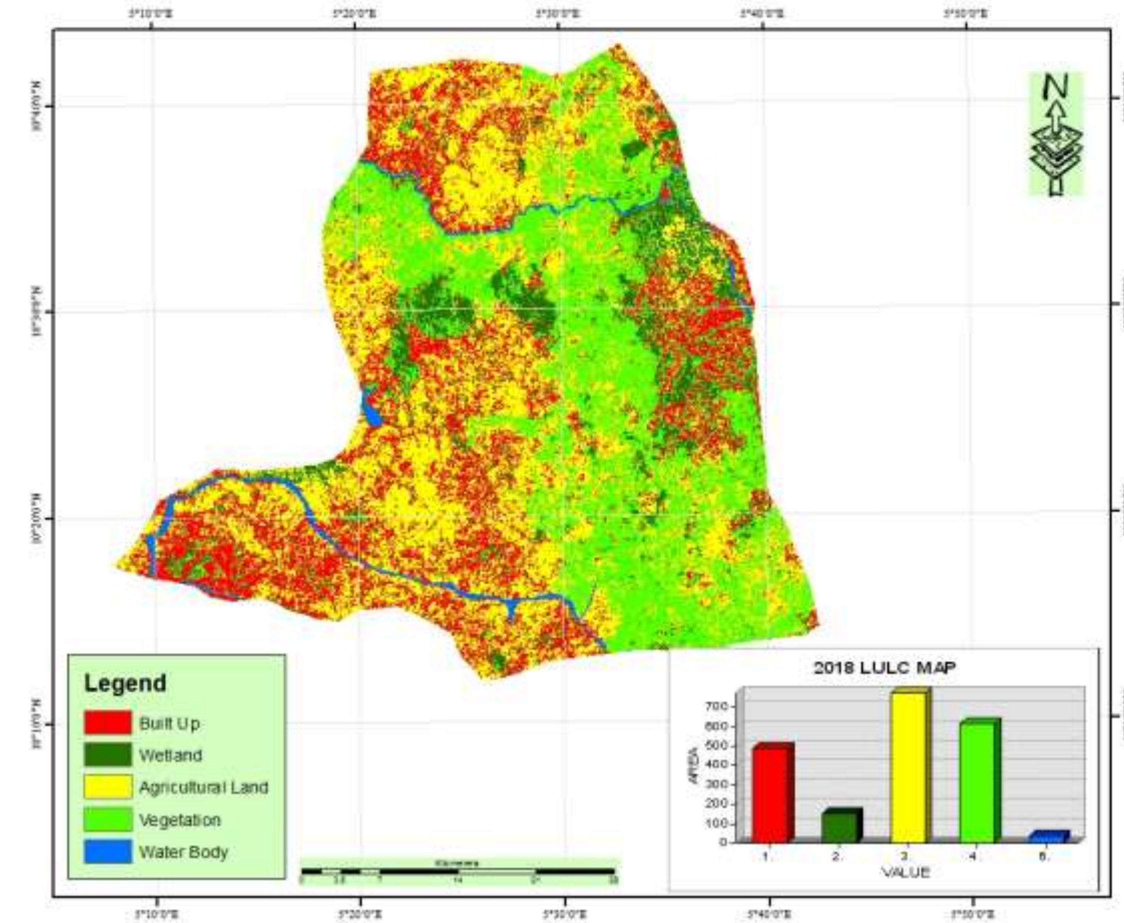


Figure 4.4 Kontagora 2018 land use/land cover distribution map generated from LandSat

Source: Author's Analysis, 2018

Table 4.1 LULC Distribution of Kontagora (1988, 1998, 2008 and 2018)

LULC	**1988**		**1998**		**2008**		**2018**	
Land Cover Category	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)
Build up	37.24	1.81	52.22	2.54	268.32	13.03	489.11	23.76
Wetland	605.52	29.43	631.02	30.65	331.63	16.11	146.56	7.12
Farmland	749.24	36.41	909.75	44.19	718.85	34.92	775.77	37.69
Vegetation	633.22	30.77	415.82	20.20	727.84	35.36	612.09	29.74
Water body	32.77	1.59	49.65	2.41	11.87	0.58	34.88	1.69
Total	2058.3	100	2058.3	100	2058.3	100	2058.3	100

Source: Author's Analysis, 2018.

In addition, Table 4.2 reveals the mean LULC change category for the Kontagora study area in terms of the area coverage for the various land use and land cover categories which shows that farmland has the highest mean value of 788.403Km2, this is followed by vegetation (597.243 Km^2), wetland (428.683 Km^2), the build-up (211.723Km^2) and water body (32.2925 Km^2). The high mean value for farmland is attributed to the fact that Kontagora has agrarian land that supports agricultural production. At the same time, wetland areas continue to decline because of the land conversion for other uses. This is further represented in Figure 4.5. which indicates the trend of change across the various land use and land cover features.

Table 4.2 Mean LULC Distribution of Kontagora (1988, 1998, 2008 and 2018)

Year	**land use and land cover Distribution of Kontagora (Area coverage in Km^2)**				
	Build up	Wetland	Farmland	Vegetation	Water body
1988	37.24	605.52	749.24	633.22	32.77
1998	52.22	631.02	909.75	415.82	49.65
2008	268.32	331.63	718.85	727.84	11.87
2018	489.11	146.56	775.77	612.09	34.88
Mean LULC Distribution	211.723	428.683	788.403	597.243	32.2925

Source: Author's Analysis, 2018

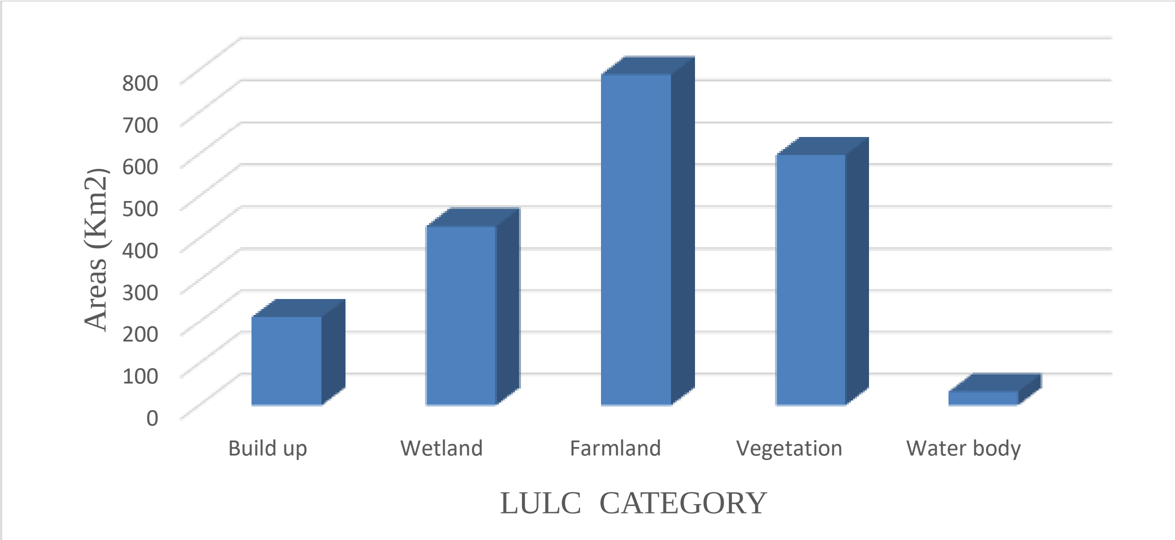


Figure 4.5:Mean LULC Distribution of Kontagora (1988, 1998, 2008 and 2018)

Source: Author's Analysis, 2018.

Furthermore, Table 4.3 shows the distribution of land use and land cover for Kontagora for the years 1988, 1998, 2008 and 2018.

Table 4.3 Mean LULC Distribution of Kontagora (1988, 1998, 2008 and 2018)

Year	**Land use and land cover Distribution of Kontagora (Area coverage)**				
	Build up	Wetland	Farmland	Vegetation	Waterbody
1988	1.81	29.43	34.17	36.41	1.59
1998	2.54	30.65	44.19	20.20	2.41
2008	13.03	16.11	34.92	35.36	0.58
2018	23.76	7.12	37.69	29.74	1.69
Mean (%) Dist.	10.29	20.83	37.74	30.43	1.57

Source: Author's Analysis, 2018

Figure 4.6 illustrates the mean percentage distribution of various land use and land cover for Kontagora over the study period 1988 to 218. The results indicated that farmland accounted for 37 %, wetland 21 %, vegetation 30 %, water body 2 %and built up area 10 % respectively.

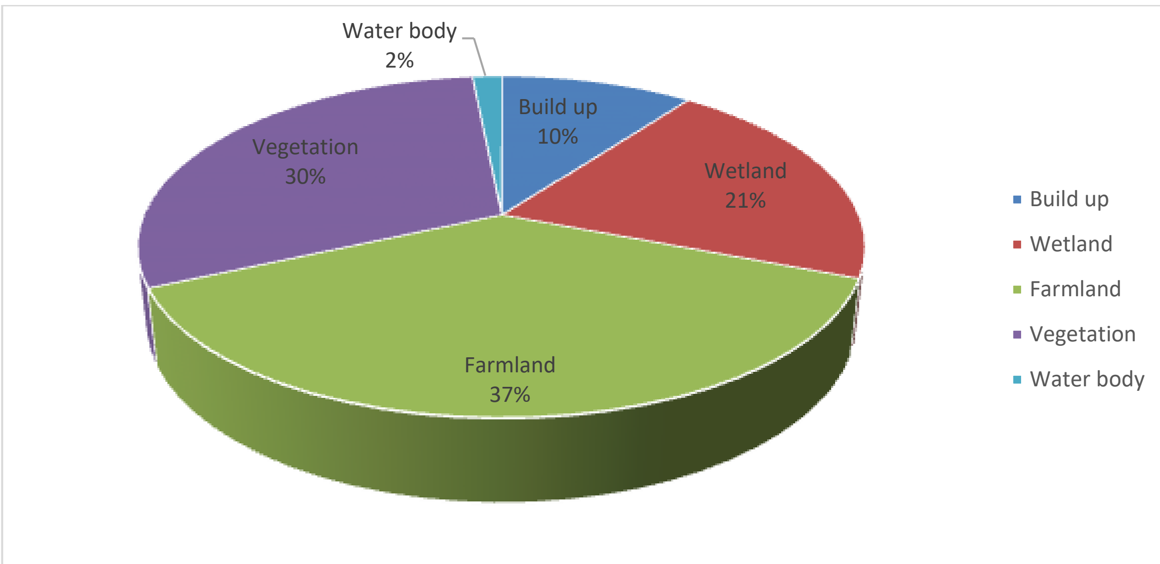


Figure 4.6. Mean (%) LULC Distribution of Kontagora (1988, 1998, 2008 and 2018)

Source: Author's Analysis, 2018

4.1.1.2 Analysis of land use/land cover classification for Bida

(a) Analysis of land use/land cover Classification of 1988 Satellite Imagery for Bida

Figure 4.7 indicates the maximum likelihood supervised classification of the Bida, which shows the area extent covered by five LULC classes (built-ups, wetland, vegetation, farmland, and water body).

The result reveals that farmland is the major LULC type in the area as of 1988. It covers an area of 11.9061Km2 (34.17%) of the total area. It is closely followed by vegetation, which occupies 10.4166 Km2 (29.89%) while built-up covers an area of 6.7527 Km2 (19.38%). Finally, Wetland and water bodies covered 5.1075 Km2 (14.66%) and 0.6588Km2 (1.89%), respectively.

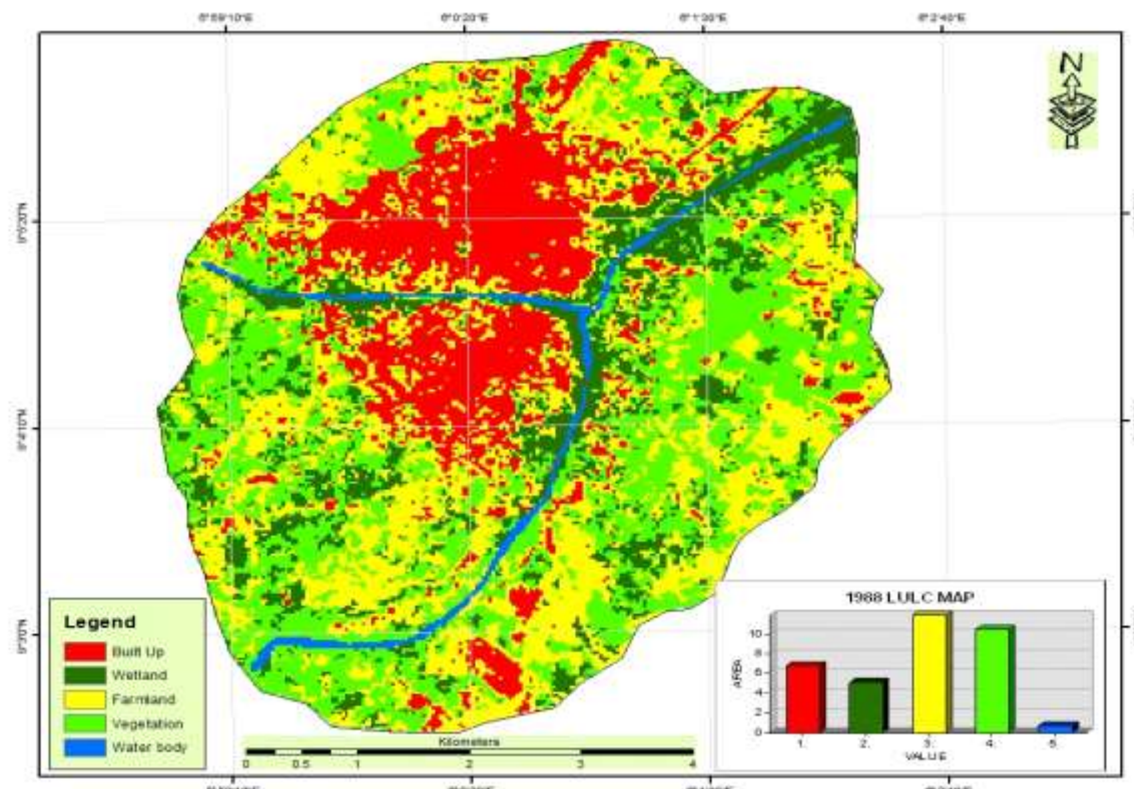


Figure 4.7:Bida 1988 LULC Distribution Map Generated from LandSat 4 TM

Source: Author's Analysis, 2018

(b) Analysis of land use/land cover Classification of 1998 Satellite Imagery for Bida

Figure 4.8 presents the LULC of the area for 1998. The map reveals that vegetation was the major LULC type with an area coverage of 12.8628Km2 (36.93%) found scattered across the study area at the northeastern, southern and some parts of the northwestern area.

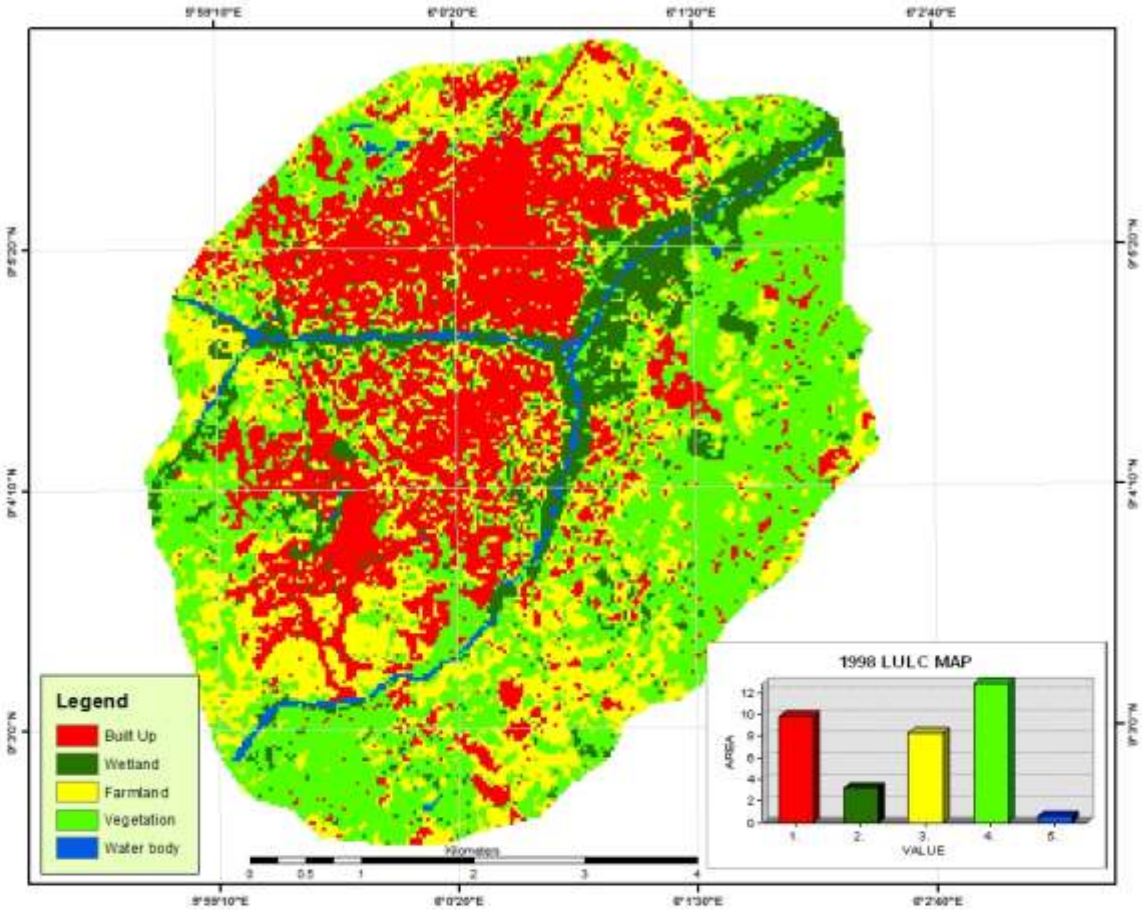


Figure 4.8: Bida 1998 LULCdistribution map generated from LandSat 4 TM

Source: Author's Analysis, 2018

This is followed by built-up areas mostly around the central and northwestern parts, covering 9.7695 Km2 (28.05%). Farmland, wetland and water body decreased from 11.9061^2

(34.17%) to 8.325 Km^2 (23.90%). 5.1075 Km^2 (14.66%) to 3.2733Km^2 (9.39%)and 0.6588Km^2 (1.89%) to 0.5967 Km^2 (1.71%), respectively.

(c) Analysis of land use/land cover Classification of 2008 Satellite Imagery for Bida

Figure 4.9 indicates the maximum likelihood supervised classification of Bida, showing the area extent covered by five LULC classes, of which Built-up is dominant. The result shows that between 1988 and 2018 significant increase has occurred in built-up, ranging from 6.7527 Km^2 (19.38%) in 1988 to 12.4119 Km^2 (35.62%) in 2008.

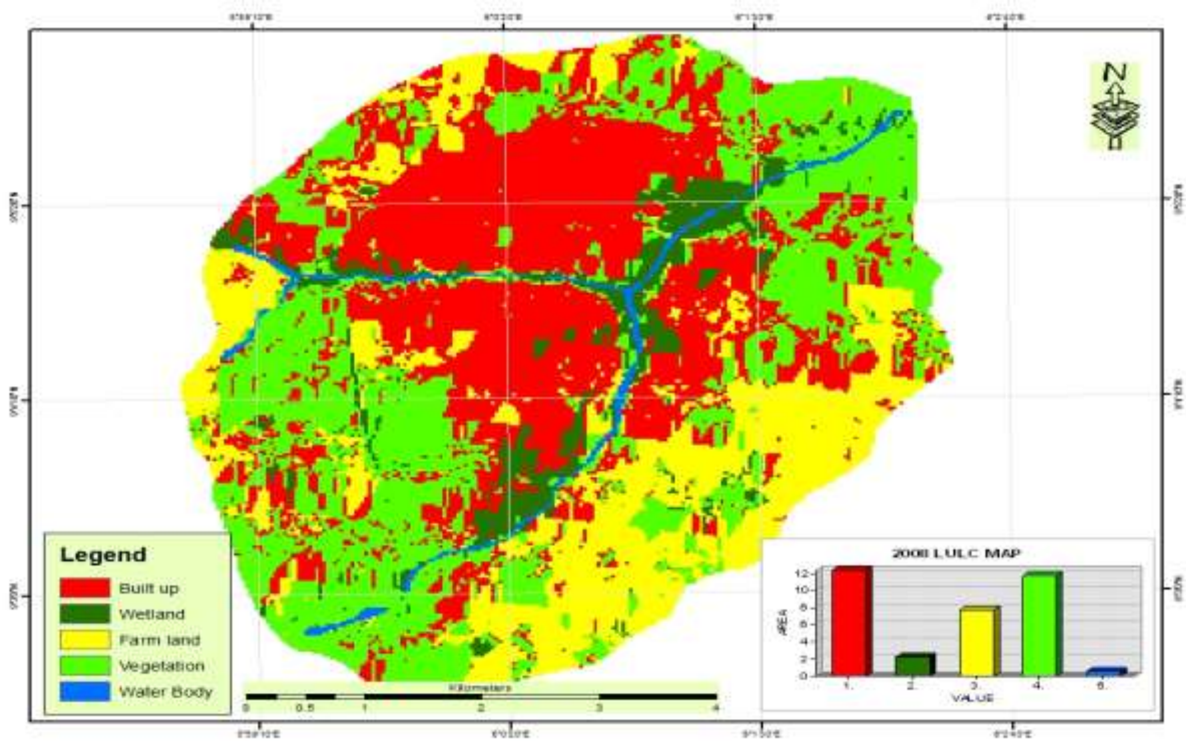


Figure 4.9: Bida 2008 LULC Distribution Map Generated from ETM+

This is followed by vegetation cover, which increases from 10.4166 km^2 in 1988 to 11.8152 km^2 (33.91%) in 2008. Farmland area decrease from 11.9061km^2 (34.17%) in 1988 to 7.7247km^2 (22.17%) in 2008. Wetland decrease from 5.1075 km^2 (14.66%) in 1988 to 2.3085km^2(6.63%). This is attributed to the continuous influx of people to the area, resulting in the conversion of wetland areas to residential areas. Water body also reduce from 0.6588km^2 (1.89%) in 1988 to 0.5823 km^2 (1.67%).

(d) Analysis of land use/land cover Classification of 2018 Satellite imagery for Bida

Figure 4.10 indicates the maximum likelihood supervised classification of the Bida for 2018,which shows the area extent covered by five LULC classes. The areal extent of each LUCL in 2018 reveals that the most dominant land use was built-up areas which shows a consistent increase during the study period. Built-up increased from 6.7527 km^2 (19.38) in 1988 to 20.4588km^2 (58.75%) in 2018. Vegetation decreases from 10.4166 km^2 $^($29.89) in 1988 to6.1317km^2 (17.61%) in 2018, farmland occupies an area of 11.9061 km^2 (34.17) in 1988 but decreases to 5.5125km^2 (15.83%) in 2018, wetland area decreases from 5.1075 km^2 in 1988 to 1.9746 km^2 (5.67%) in 2018, water body shows increase from 0.6588 km^{2}in 1988 to 0.747 km^2 (2.15%) in 2018. The statistic of the areal extend for each of the LULC categories are summarized in Table 4.4

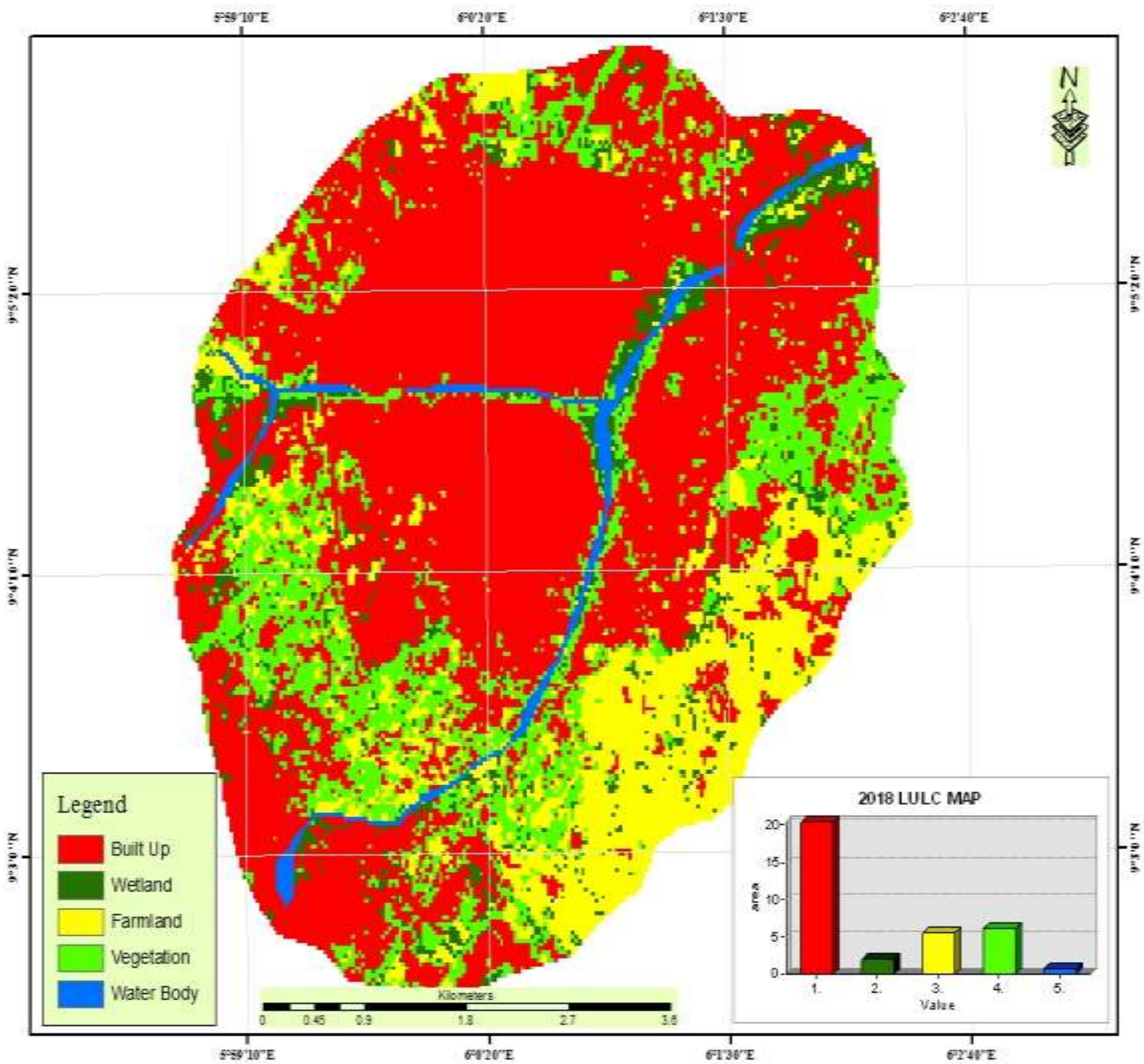


Figure 4.10: Bida 2018 Land use/Land cover Distribution Map Generated from Operation Land Imager (OLI)

Source: Author's Analysis, 2018.

Table 4.4 land use and land cover Distribution of Bida (1988, 1998, 2008 and 2018)

LULC	**1988**		**1998**		**2008**		**2018**	
Land Cover Category	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)
Build up	6.7527	19.38	9.7695	28.05	12.4119	35.62	20.4588	58.75
Wetland	5.1075	14.66	3.27	9.39	2.3085	6.63	1.9746	5.67
Farmland	11.9061	34.17	8.325	23.90	7.7247	22.17	5.5125	15.83
Vegetation	10.4166	29.89	12.86	36.93	11.8152	33.91	6.1317	17.61
Water body	0.6588	1.89	0.59	1.71	0.5823	1.67	0.747	2.15
Total	34.8417	100	34.8417	100	34.8417	100	34.8417	100

Source: Author's Analysis, 2018.

Furthermore, Table 4.5 reveals the mean changes in LULC Distribution of Bida in square kilometres during the study period (1988- 2018). The result shows that built-up areas have the highest mean value of 12.35km^2, followed by wetland (3.17 km^2), vegetation (10.31km^2), and farmland (8.37km^2),whereas water body has the lowest with 0.65 km^2.

Table 4.5: Mean LULC Distribution of Bida (1988, 1998, 2008 and 2018)

Year	**land use and land cover Distribution of Bida (Area coverage in Km^2)**				
	Build up	Wetland	Farmland	Vegetation	Waterbody
1988	6.7527	5.1075	11.9061	10.4166	0.6588
1998	9.7695	3.27	8.325	12.86	0.59
2008	12.4119	2.3085	7.7247	11.8152	0.5823
2018	20.4588	1.9746	5.5125	6.1317	0.747
Mean	12.35	3.17	8.37	10.31	0.65

Source: Author's Analysis, 2018

Figure 4.11 depicts the mean values of the various land use and land cover category to give a clearer representation of the changes that have taken place over time and space in the study area. The result shows that water body and wetland has the lowest mean value of 0.65 and 3.17 respectively, while built areas have the highest with 12.35.

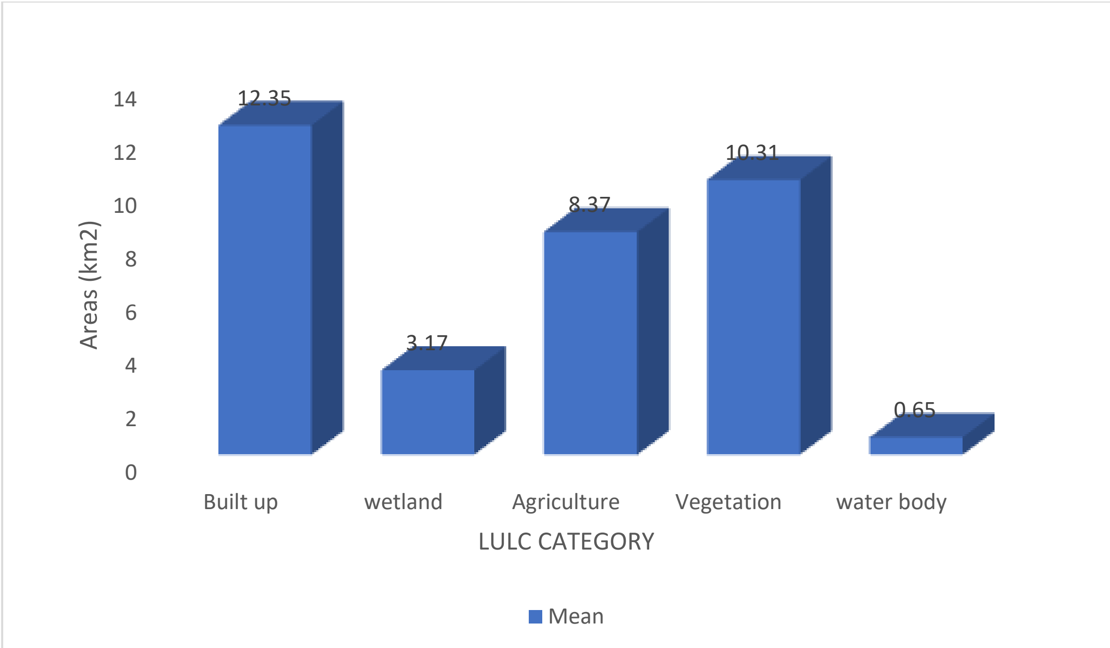


Figure 4.11: Mean LULC Distribution of Bida (1988, 1998, 2008 and 2018)

Source: Author's Analysis, 2018

Table 4.6and Figure 4.12 show the Mean (%) LULC Distribution of Kontagora; it also reveals that build-up has the highest percentage with 35.45%, whereas the water body has the lowest with 1.86%. across the forty years study periods

Table 4.6 Mean (%) LULC Distribution of Bida (1988, 1998, 2008 and 2018)

Year	**Land use and land cover Distribution of Bida (Area coverage in %)**				
	Build up	Wetland	Farmland	Vegetation	Waterbody
1988	19.38	14.66	34.17	29.89	1.89
1998	28.05	9.39	23.90	36.93	1.71
2008	35.62	6.63	22.17	33.91	1.67
2018	58.75	5.67	15.83	17.61	2.15
Mean	35.45	9.09	24.02	29.59	1.86

Source: Author's Analysis, 2018

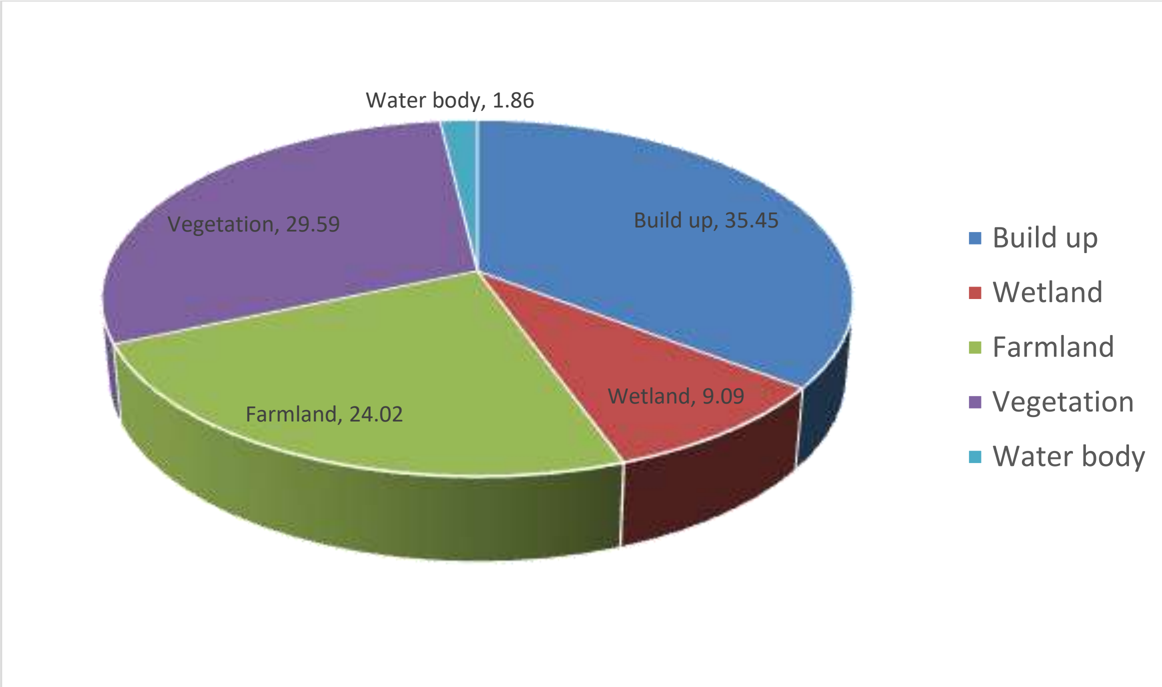


Figure 4.12:Mean LULC Distribution of Bida (1988, 1998, 2008 and 2018)

Source: Author's Analysis, 2018

4.1.1.3 Analysis of land use/land cover Classification for Chanchaga

(a) Analysis of land use/land cover Classification of 1988 Satellite Imagery for Chanchaga

Figure 4.13 is a classified LULC map of Chanchaga showing the five classes under study. It reveals that vegetation, farmland, and wetland are the largest with1610.747km² (42.91%), 996.1398km² (26.54%), and 568.6776km² (20.43%), respectively. Built-up and water bodies are the smallest, with about 546.7518km² (14.57%) and 31.1526km² (0.83%).

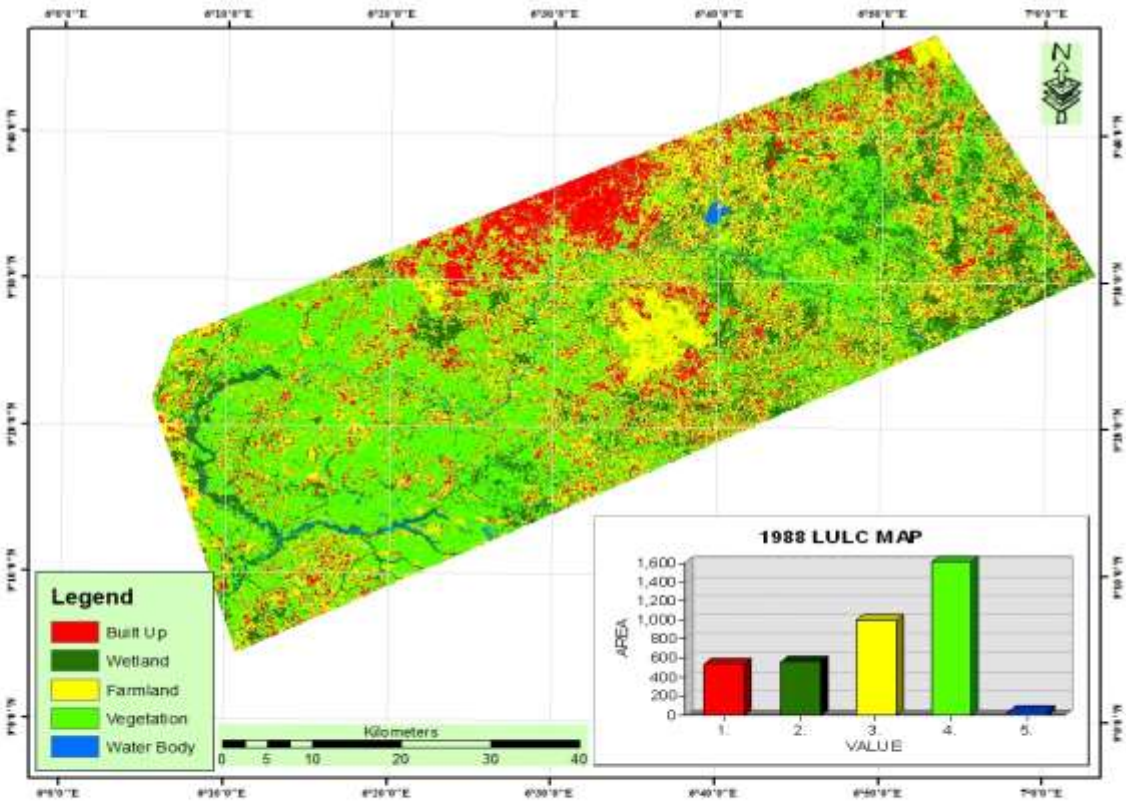


Figure 4.13: Chanchaga 1988 Land use/Land cover Distribution Map Generated from TM4

(b) Analysis of land use/land cover Classification of 1988 Satellite Imagery for Chanchaga

Figure 4.14 is a classified map of the study area for 1998. The result shows that vegetation, farmland, and built-up areas have the largest area coverage of 1324.504km² (35.29%), 1141.513km² (30.41%), and 748.3347km² (19.94%) respectively, while wetland and water body were the smallest areas with 511.1928km² (13.62%) and 28.1367km² (0.75%) of the total land area.

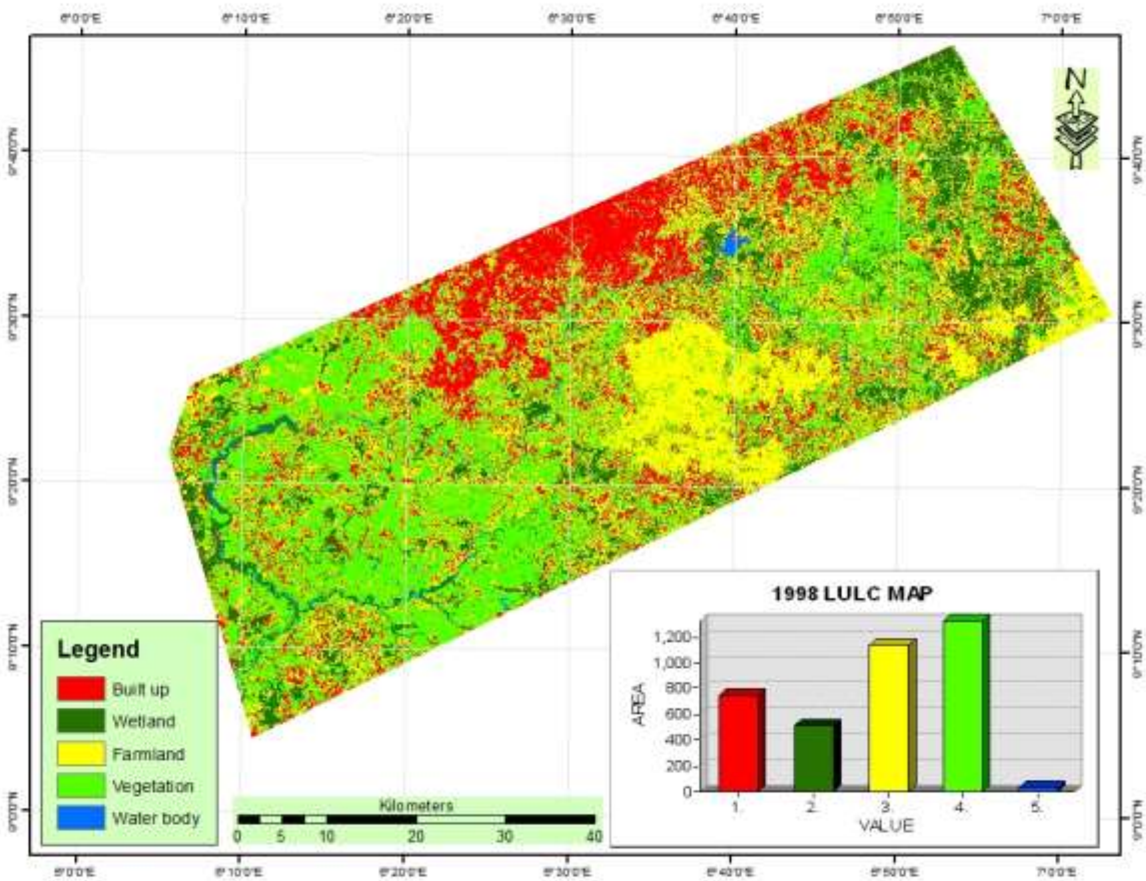


Figure 4.14: Chanchaga 1998 Land use/Land cover Distribution Map Generated from TM4

(c) Analysis of land use/land cover Classification of 2008 Satellite Imagery for Chanchaga

Figure 4.15 indicates the LULC map of the study area for the year 2008. The map shows that there were continuous changes in the various LULC category. The map also revealed that vegetation, farmland and built-up areas constitute the highest coverage with1292.941km² (34.44%), 1186.282km² (31.60%), and 848.88km² (22.61%) respectively, while wetland and water body covered the smallest 398.4318km² (10.61%) and 27.1305km² (0.72%) respectively.

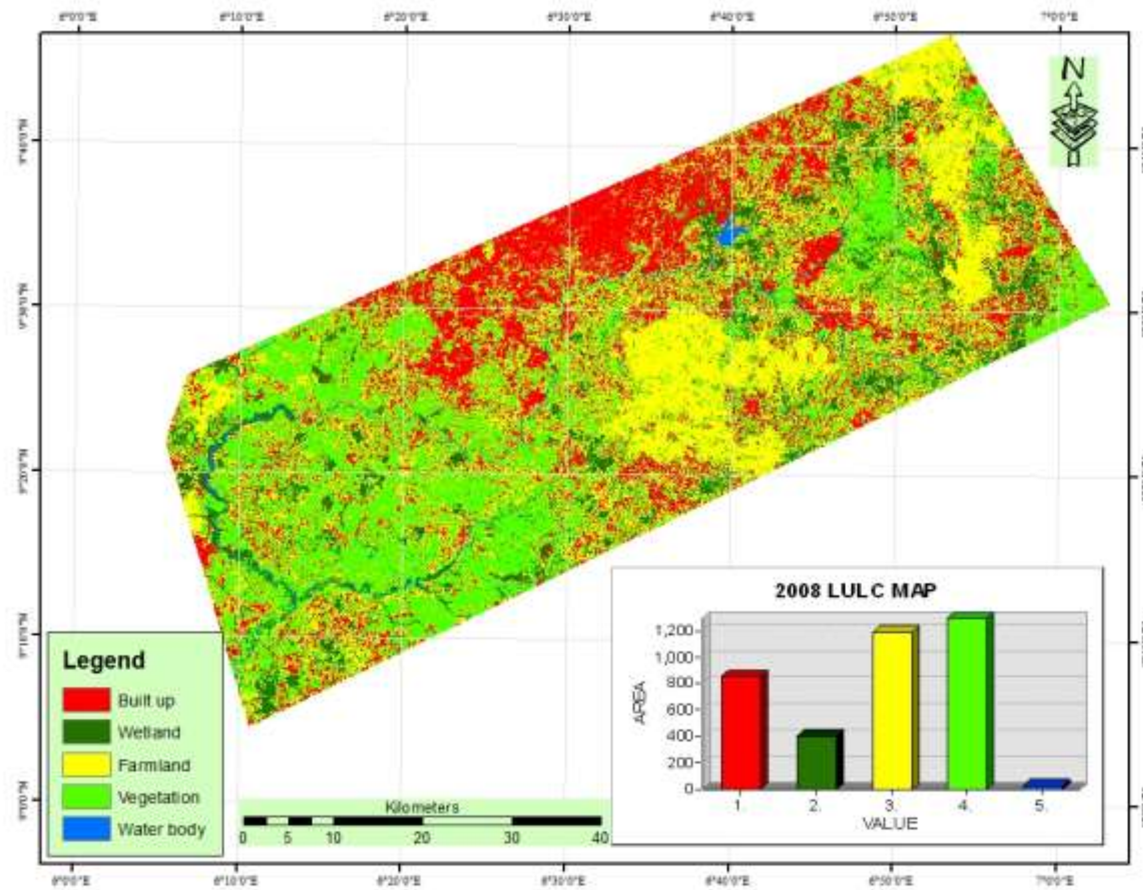


Figure: 4.15: Chanchaga 2008 Land use/Land cover Distribution Map Generated from TM4

(d) Analysis of land use/land cover Classification of 2018 Satellite Imagery for Chanchaga

Figure 4.16 shows the LULC map of the area for 2018, and the map shows that built-up areas have increased tremendously over time from 546.7518km² (14.57%) in 1988 to 1146.758km²(30.55%).Further, farmlands and vegetation areas constitute the highest with 1169.972 km² (31.17%) and 1157.248 km² (30.83%), respectively. On the other hand, the wetland area and water body occupy 252.1296 km² (6.72%) and 27.5733 km² (0.73%). Throughout the study, the increase in farmland area shows that the area's people are farmers who engage in agricultural activities, as indicated in the plate I. In contrast, the increase in built-up areas indicates that people are moving away from the urban to peri-urban areas for agricultural purposes. The areal coverage of each land use category was summarized in Table 4.

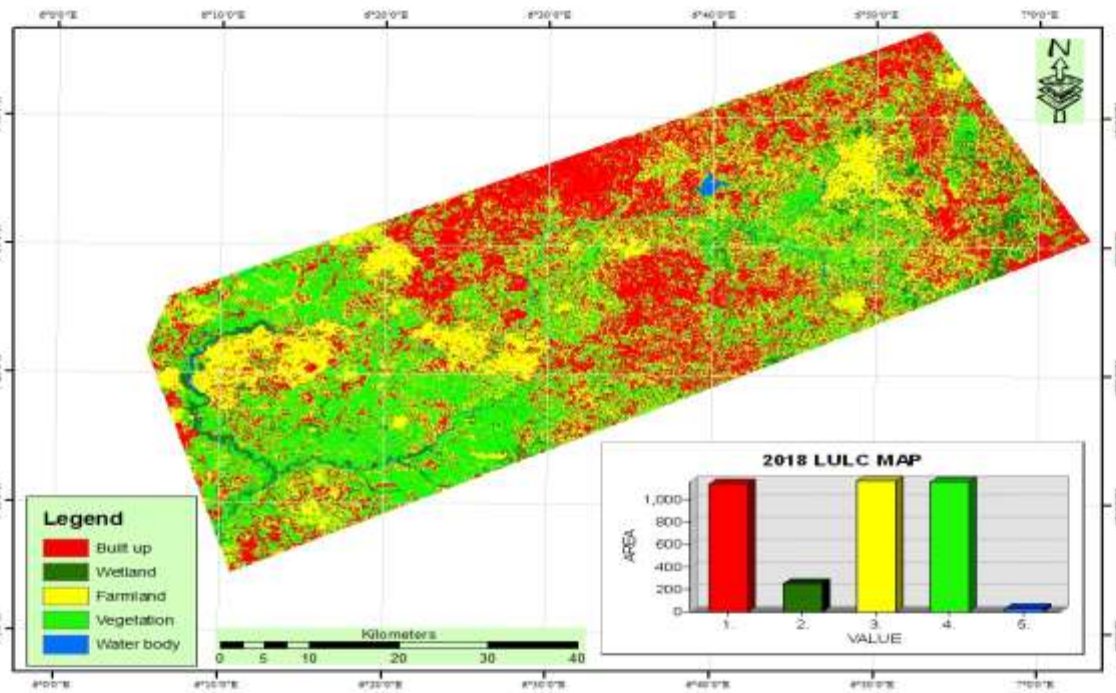


Figure 4.16: Chanchaga 2018 Land use/Land cover Distribution Map Generated from OLI

Plate I: Wetland area Converted to Agricultural Land

Table 4.7 land use and land cover Distribution of Chanchaga (1988, 1998, 2008 and 2018)

LULC	1988		1998		2008		2018	
Land Cover Category	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)
Build up	546.7518	14.57	748.3347	19.93	848.88	22.61	1146.758	30.55
Wetland	568.6776	15.15	511.1928	13.62	398.4318	10.61	252.1296	6.72
Farmland	996.1398	26.54	1141.5132	30.41	1186.282	31.60	1169.972	31.17
Vegetation	1610.7471	42.91	1324.5039	35.29	1292.941	34.44	1157.248	30.83
Water body	31.1526	0.83	28.1367	0.75	0.5823	0.72	27.5733	0.73
Total	3753.4689	100	3753.4689	100	3753.4689	100	3753.4689	100

Source: Author's Analysis, 2018.

Table 4.8 shows the mean LULC distribution of Chanchaga in square kilometres over the 40 years study period (1988-2018). The result shows that vegetation has the highest mean value of 1346.36 km^2 of land area. This is followed by farmland and built-up areas with1123.48 km^2 and 822.68 km^2, respectively; the wetland has 432.61 $km^{2,}$whereas the water body is the lowest with21.86 km^2.

Table 4.8 Mean LULC Distribution of Chanchaga (1988, 1998, 2008 and 2018)

year	land use and land cover Distribution of Chanchaga (Area coverage in Km^2)				
	Build up	Wetland	Farmland	Vegetation	Waterbody
1988	546.7518	568.6776	996.1398	1610.7471	31.1526
1998	748.3347	511.1928	1141.5132	1324.5039	28.1367
2008	848.88	398.4318	1186.282	1292.941	0.5823
2018	1146.758	252.1296	1169.972	1157.248	27.5733
Mean LULC Dist.	822.68	432.61	1123.48	1346.36	21.86

Source: Author's Analysis, 2018

Figure 4.17 shows the mean LULC distribution for Chanchaga, and the result shows that vegetation has the highest mean value with 1346.36 km^2while the water body has the lowest with 21.86 km^2. The further result shows that wetland recorded a mean value of 432.61 $km^{2,}$whereas build-up and farmland have 822.68 km^2 and 1123.48 km^2.

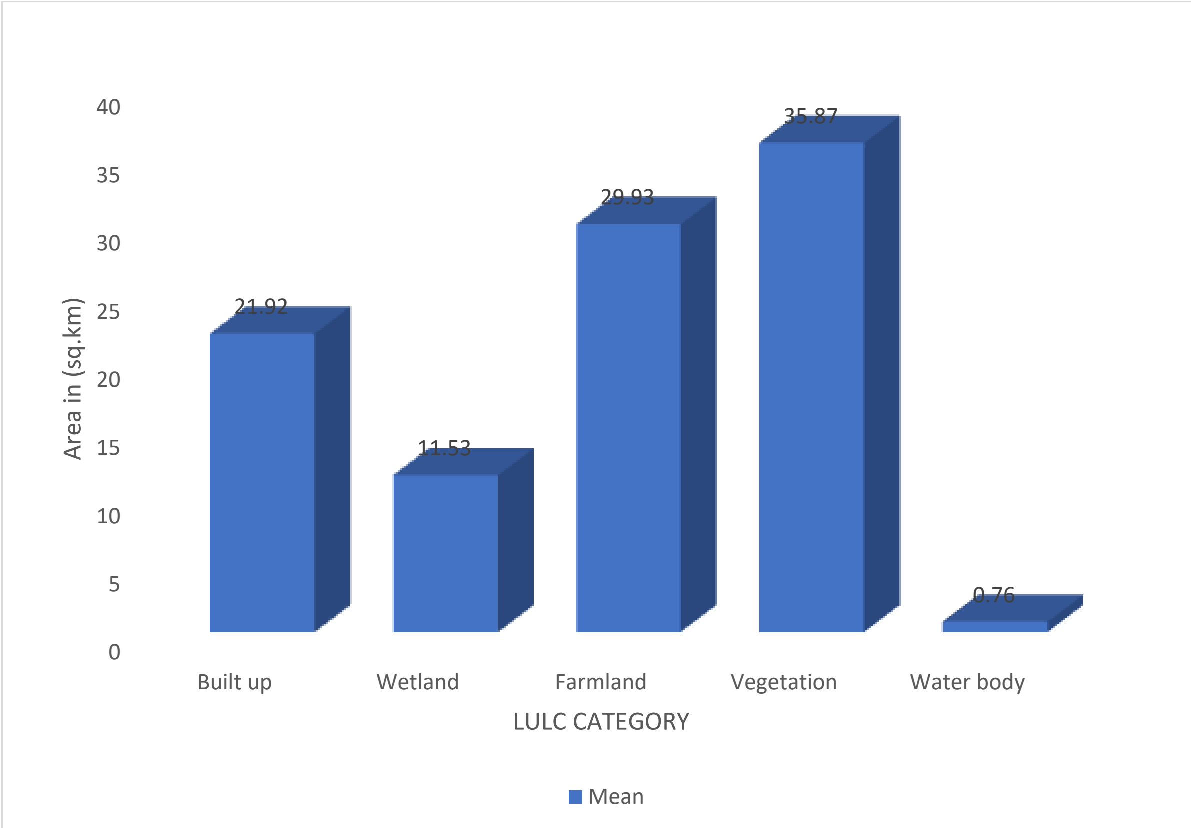


Figure 4.17:Mean LULC Distribution of Chanchaga (1988, 1998, 2008 and 2018)

Sources: Author's analysis, 2018.

Table 4.9 and Figure 4.18indicate the mean percentage distribution of LULC in the area, and the result reveals that vegetation has the highest mean value percentage of 35.87%, followed by farmland (29.93%) built-up(21.92%), respectively. On the other hand, Wetland and water body decreases steadily to 11.53% and 0.76% respectively.

Table 4.9: Mean (%) LULC Distribution of Chanchaga (1988, 1998, 2008 and 2018)

year	Land use and land cover Distribution of Chanchaga (Area coverage in %)				
	Build up	Wetland	Farmland	Vegetation	Waterbody
1988	14.57	15.15	26.54	42.91	0.83
1998	19.93	13.62	30.41	35.29	0.75
2008	22.61	10.61	31.60	34.44	0.72
2018	30.55	6.72	31.17	30.83	0.73
Mean	21.92	11.53	29.93	35.87	0.76

Source: Author's Analysis, 2018

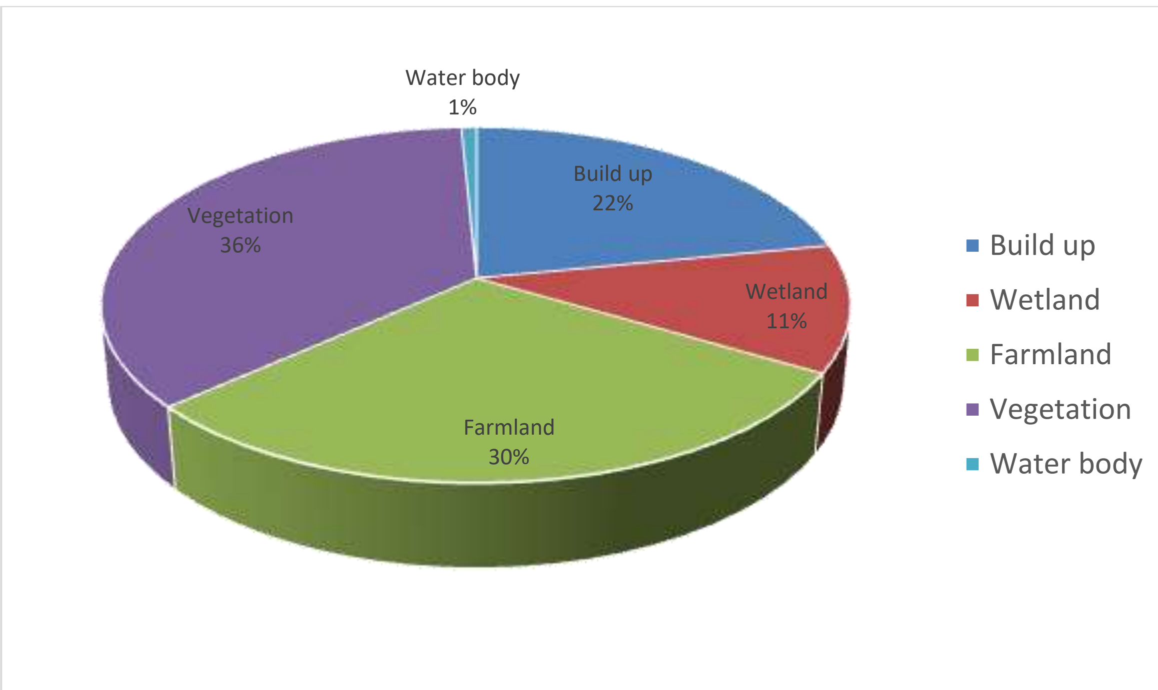


Figure 4.18: Mean (%) LULC Distribution of Chanchaga (1988, 1998, 2008 and 2018)

Sources: Author's analysis, 2018.

4.1.1.4 Summary of the Spatio-temporal Analysis of LULC of the Study Area

Table 4.10and Figure 4.19 show the mean statistic of the comparative analysis of land use and land cover category of the study locations(Kontagora, Bida and Chanchaga). The result shows Chanchaga has the highest for all the classes considered; Kontagora follows this while Bida has the lowest. For example, build up and wetland areas in Chanchaga have 822.68 km^2 and 432.61 km^2, Kontagora has 211.72 km^2 and 428.68 $km^2$for buildup and wetland, whereas Bida is lowest with 12.35 km^2 and 3.17 km^2 for buildup and wetland, respectively.

Table 4.10 Summary of the Spatio-temporal Analysis of LULC of the Study Areas (1988, 1998, 2008 and 2018)

Land Cover Category	Kontagora	Bida	Chanchaga
Build up	211.723	12.35	822.68
Wetland	428.683	3.17	432.61
Farmland	788.403	8.37	1123.48
Vegetation	597.243	10.31	1346.36
Water body	32.2925	0.65	21.86

Source: Author's Analysis, 2018

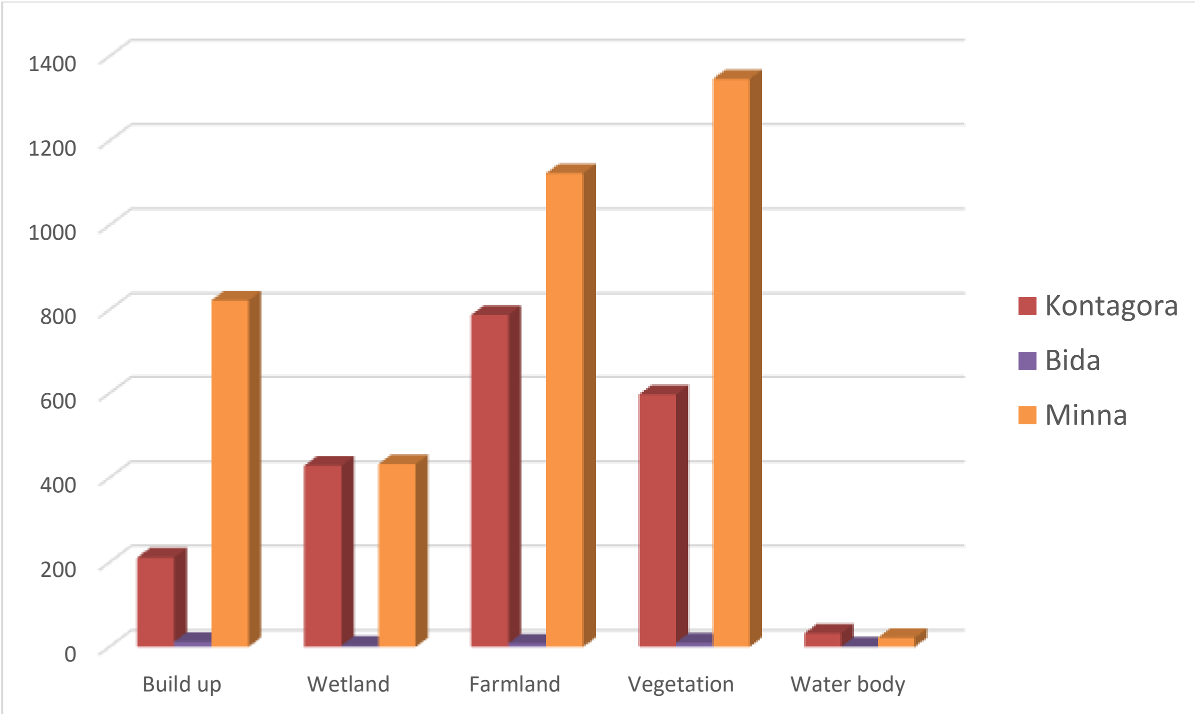


Figure 4.19: Summary of the Spatio-temporal Analysis of LULC of the study area (1988, 1998, 2008 and 2018)

4.2 Effects of Human Activities on Wetlands Through Urbanization

The effects of human activities on the wetland ecosystem are analysed across the three study locations, and the results are discussed below using the Normalized Difference built-up Index (NDBI):

4.2.1.1: Analysis of the Effects of Human Activities on Wetlands Through Urbanization in Bida

Figure 4.20 presents the NDBI maps of the study area for the years(1988-2018) across the study area of Bida. The pixels with red pigments on the NDBI maps were classified as having high values which represent places with high built-up areas, pixels with yellow pigment were classified as having a medium value which signifies areas with bare soil or partially built-up areas cover, while pixels with green colours on the NDBI maps signifies area with high water cover or wetland areas. The maps show that the rate of built-up areas has increased from 1988 to 2018 with a high concentration in City Centre.

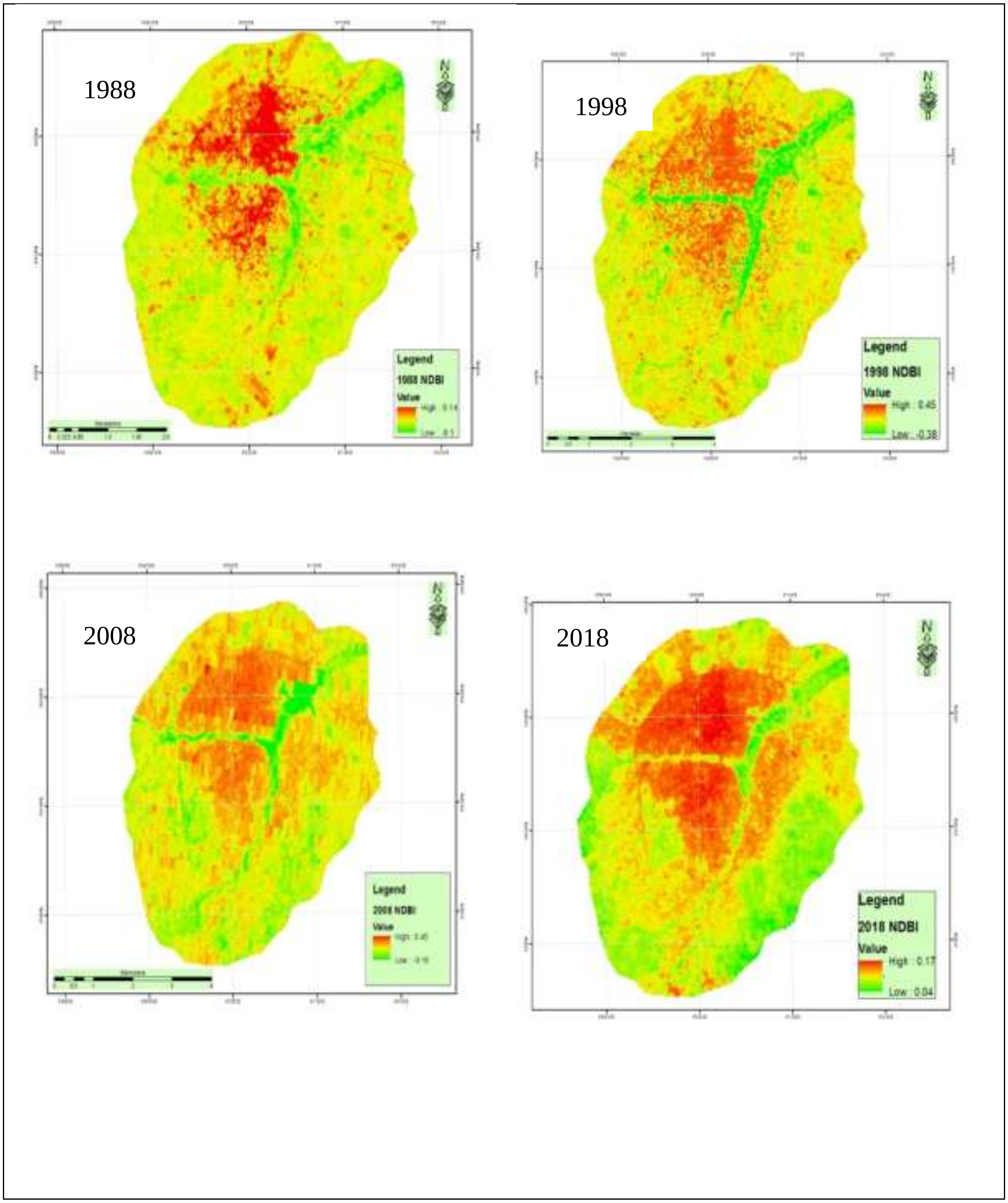
A higher NDBI value implies a high level of urbanization in the area, while low values indicate low urbanization. This is because Built-up areas exhibit higher heat conductivity than bare soil, vegetation and water body areas, resulting in the higher emissivity and albedo values of thermal infrared waves in built-up areas relative to bare soil and other areas. This is in line with the work of (Daramola *et al.*, 2019), who analysis the effect of urbanization on the surface water of Landzun stream Bida.

Plate II: Human Activities on Landzun Wetland Area.

Plate II shows observed scenes of human activities along the Landzun Stream channel during field studies. (A, & D) Inhabitants washing household utensils, (B) Children bathing in the channel (C) The spring source of Landzun Stream.

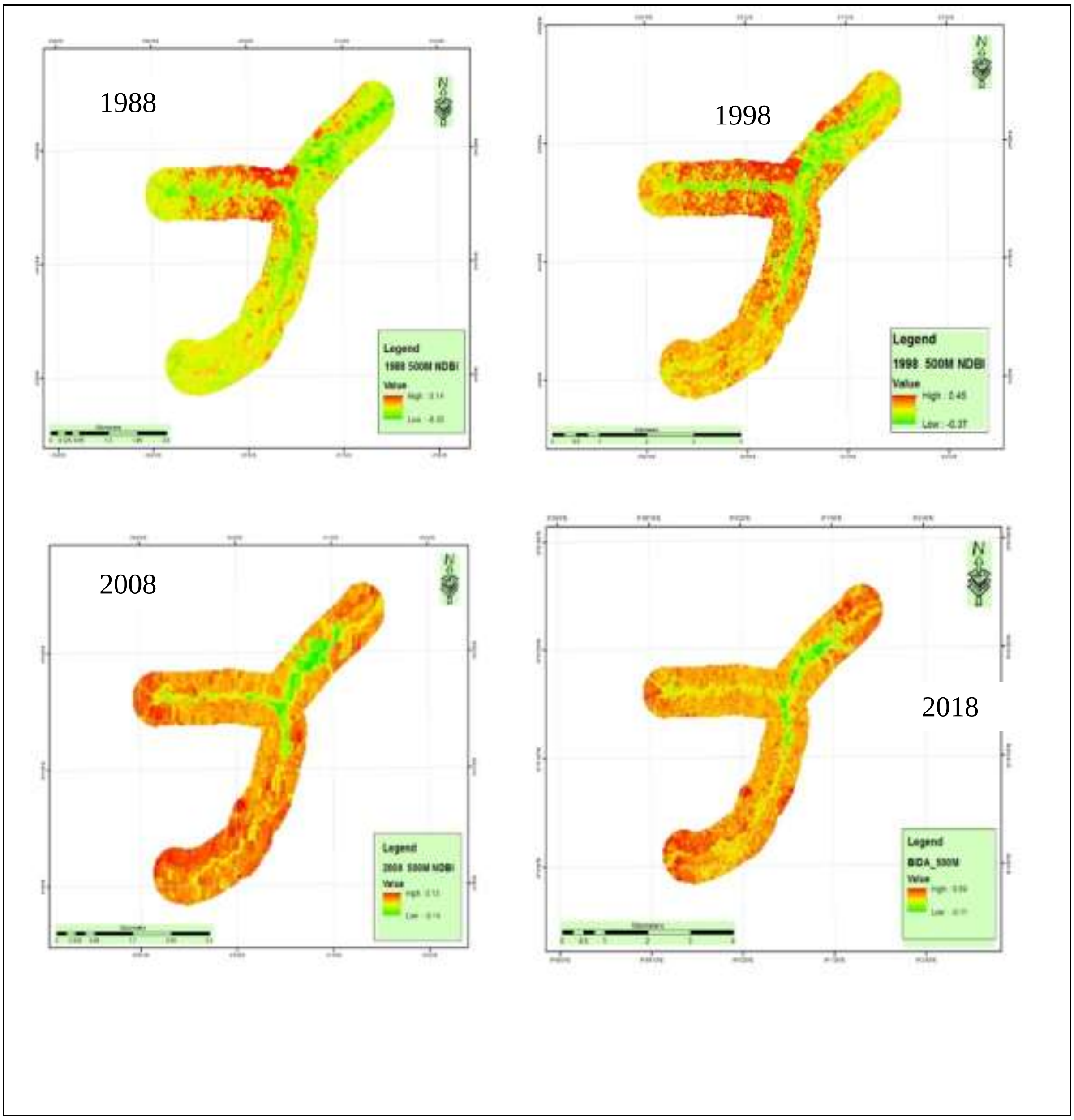
Plate III: Urban Encroachment on Landzun Wetland Area

Plate III depicts possible contamination linkages around the Landzun Stream as a result of human activities, (A) Discharge of automobile wash wastewater to the Stream, (B) Palm tree plantation by river channel, (C) Animals grazing around the channel, (D) Millet farm flanking the channel.



4.20: Normalized Difference Build-up Index map of Bida (1988, 1998, 2008 & 2018).

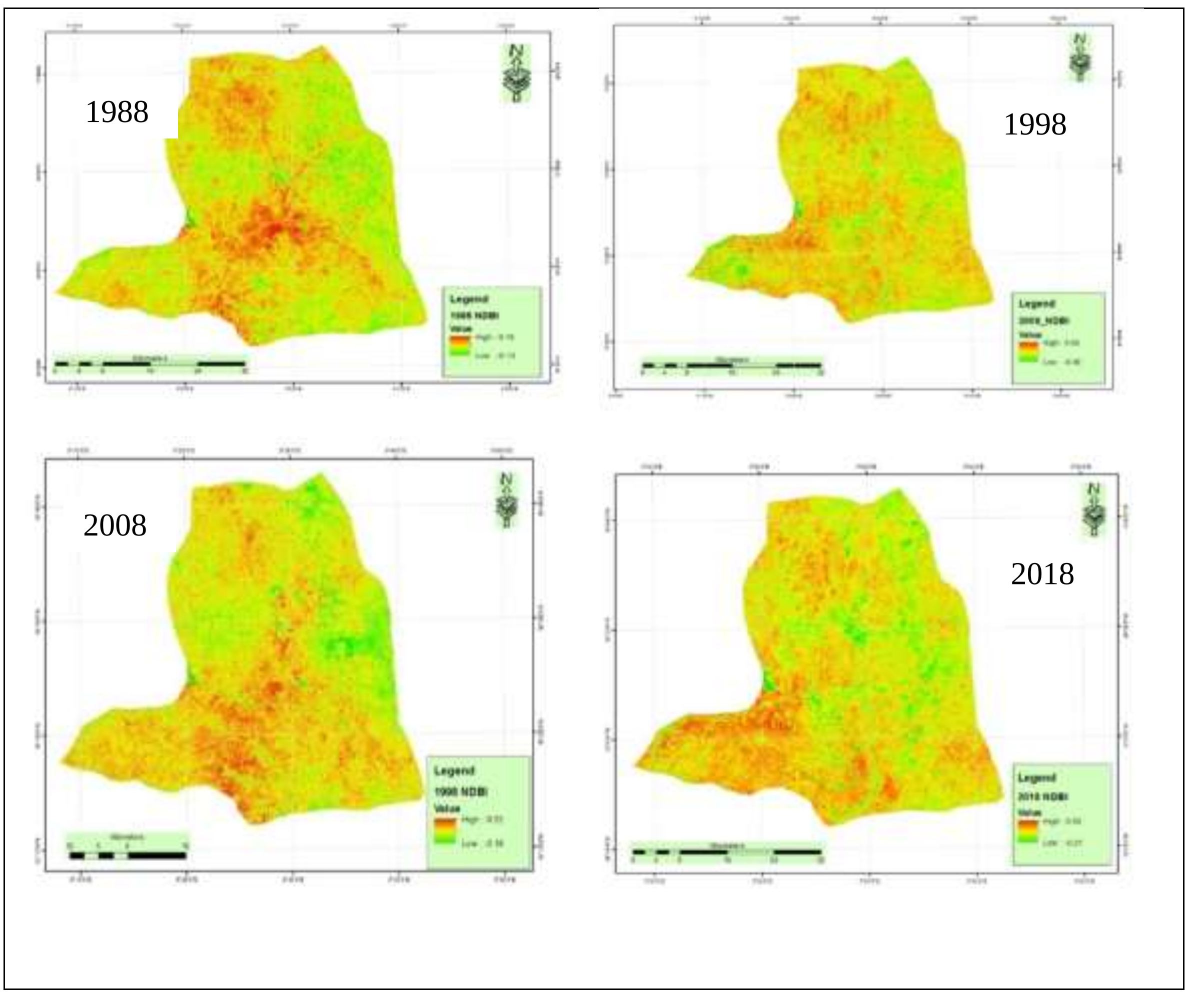
The NDBI values continued to increase from 0.16 in 1988 to 0.17 in 2018. The increase in NDBI values indicates deforestation/ less vegetal cover or possibly due to an increase in developmental activities. The implication of high NDBI cover will result in direct solar radiation and hence a higher evaporation rate leading to inadequate moisture; these will negatively affect the normal functions of the wetland ecosystem.



4.21: Normalized Difference Build-up Index map of Bida500M (1988, 1998, 2008 & 2018)

Similarly, figure 4.21: Normalized Difference Build-up Index map of Bida500M (1988, 1998, 2008 & 2018) shows the 500-meter buffer of the study area in Bida, it indicates that the indices were high with 0.14 and -0.03 low in 1988, 0.04 high and -0.37 low in 1998, while in 2008 and 2018 it reads 0.13 high, -0.14 low and 0.09 high and 0.11 low respectively most especially at the core city Centre section of the map where they are the concentration of building whereas in the year 2018 built-up areas have increased tremendously across the entire area with varying degree of red, yellow and green pigment which represent high, moderate and water body respectively.

4.2.1.2 Analysis of the effects of human activities on wetlands through urbanization in Kontagora

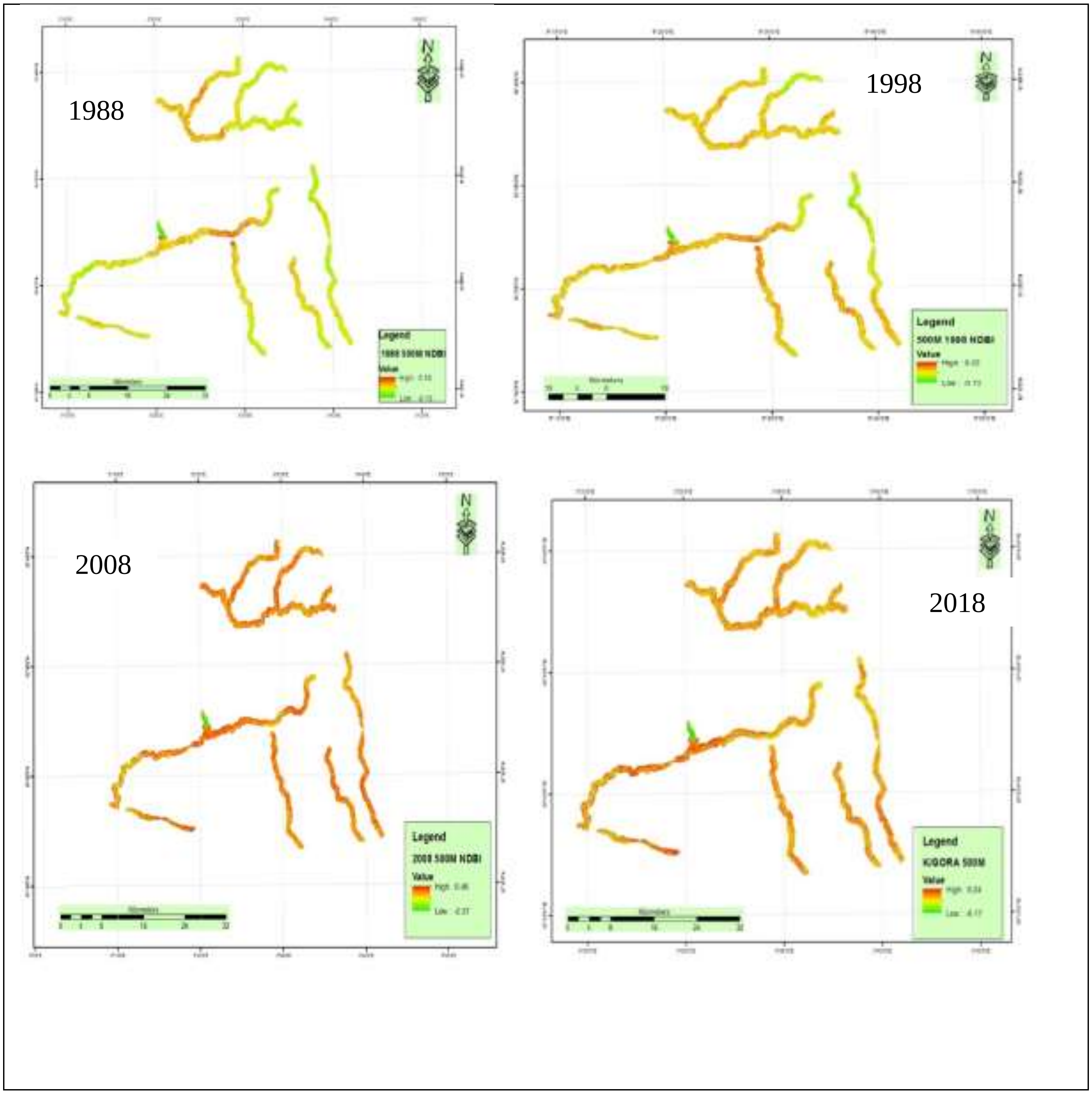


4.22: Normalized Difference Build-up Index map of Kontagora (1988, 1998, 2008 & 2018)

The effects of human activities revealed on the Normalized Difference Built-up Index (NDBI) map of Kontagora for (1988, 1998, 2008 & 2018) as shown in figure 4.22.The pixels with red pigments on the NDBI maps were classified as having high values, which represent places with high built-up areas, found especially at the western, southern and Centre and the northern section of the maps, pixels with yellow pigment were classified as having a medium value which signifies areas with bare soil or partially built-up areas cover. In contrast, pixels with green colours on the NDBI maps signify areas with high water cover or wetland areas. This is seen clearly that the waterworks water and wetland areas were completely green from the maps; also, it can be seen that the rate of built-up having been on the increase from 1988 to 2018 with a high concentration of built up at the City Centre.

Human activities imply that there will be increased solar radiation and surface storage of storm water. The results showed increased surface run-off (resulting in increased surface water input to wetland). Similarly, increased storm water discharge relative to base-flow discharge results in increased erosive force within stream channels. This results in increased sediment inputs to recipient coastal systems, occurring in water quality (increased turbidity, increased nutrients, metals, organic pollutants, decreased oxygen concentration). Alterations in shape and slopes (e.g. convexity) affects water-gathering or waste-disseminating properties, and Fragmentation of wetland habitats can also impact the fauna that depends on these ecosystems for habitat and food particularly those with specific needs.

In addition, Figure. 4.23indicates the Normalized Difference Build-up Index map of the Kontagora 500M (1988, 1998, 2008 & 2018) buffer. It reveals that built-up areas are on the increase towards the wetland areas across the different epoch under consideration due to the fertility of the soil, which supports the provision of stable and fresh vegetables for farmers family in-take and sales to the general public as one of the main benefits they derived in such areas. In other words, economic gains in terms of poverty reduction, food security are some of the factors attracting inhabitants of those areas to continue depleting the wetland ecosystem.



4.23: Normalized Difference Build-up Index map of Kontagora 500M (1988, 1998, 2008 & 2018)

Source: Author's Analysis, 2018

4.2.1.3 Analysis of the effects of human activities on wetlands through urbanization in Chanchaga

From the maps, it can be seen that the rate of the building has been on the increase from 1988 to 2018 with a high concentration of built upon the northern section of the map toward Chanchaga centre.

The low NDBI value in this area can be attributed to the fact that the area comprises mainly peri-urban settlement, which usually has settlements scattered over and not concentrated as compacted urban centres. However, the area has continued to witness urbanization resulting. Furthermore, urbanization brings about the depletion of the wetland ecosystem because of the benefits derived from the areas. The result indicates that more rapid urbanization has been taking place in the study area from2008 to 2018than the two other periods of 1988 and 1998.

The high NDBI values imply that urbanization in wetland areas will result inhydrological change, which is the most visible impact of urbanization and strongly influences water quality, in addition to the hydrodynamic variables within the system, Direct habitat destruction and alteration, Decreased groundwater recharge results in decreased groundwater flow, which reduces base flow and may eliminate dry- season stream flow as well as the increased cross-sectional area of stream channels (due to erosional effects of increased flood peak flow) increases erosion along banks

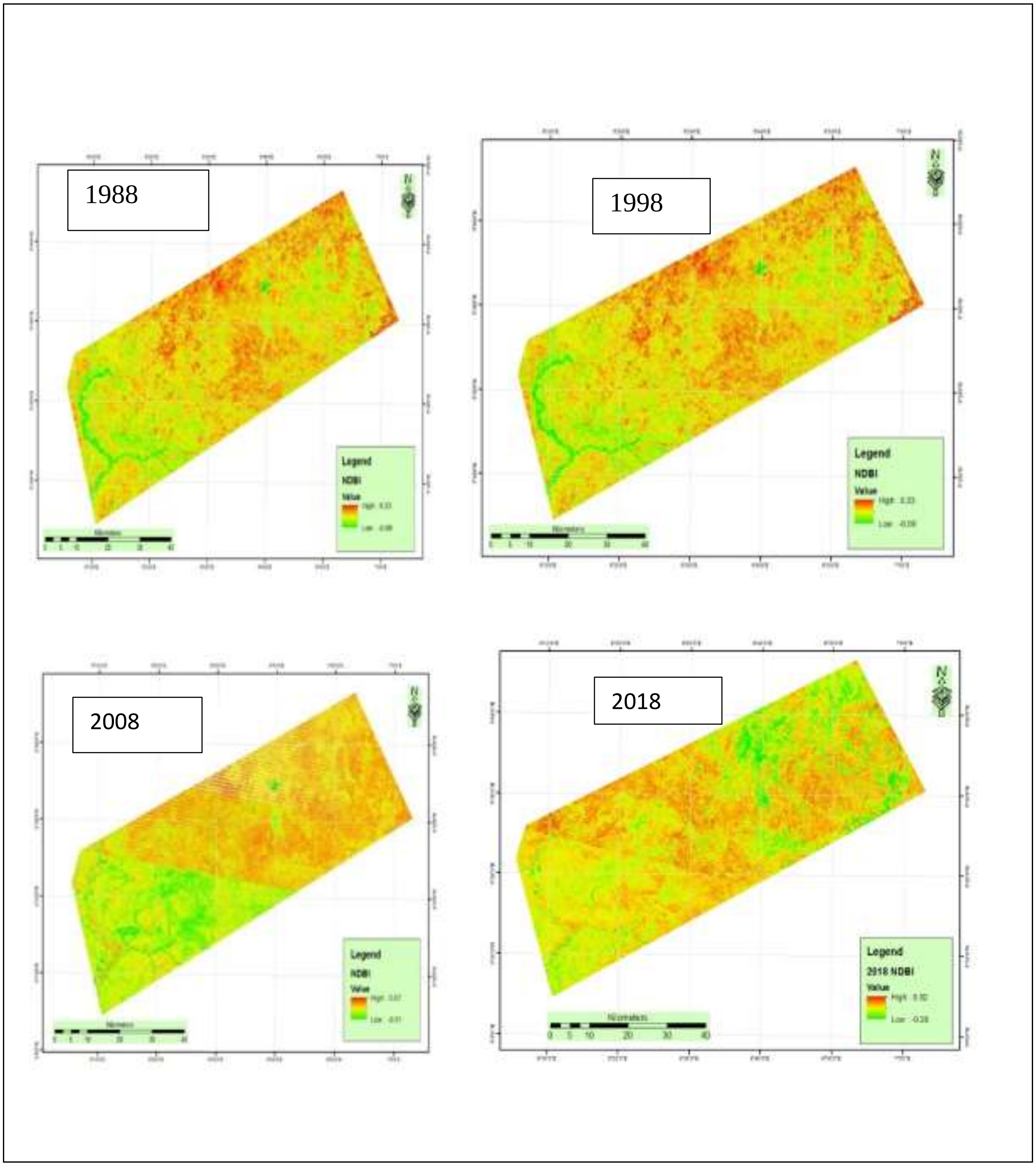


Figure 4.24: Normalized Difference Build-up Index map of Chanchaga (1988, 1998, 2008 & 2018)

Similarly, figure 4.25 reveals the Normalized Difference Build-up Index map of the Chanchaga1km buffer (1988, 1998, 2008 & 2018). The results on the maps indicate that NDBI was low in 1988 (0.19) and high in 2018 with a value of (0.27). This increase in built-up implies that there will be an increase in the range of flow rates (low flows are diminished; high flows are augmented) may deprive wetlands of water during dry weather, and greater regulation of flows decreases the magnitude of the spring flush. Hence, if measures are not put in place to check the continuous depletion of the wetland ecosystem, all the important services provided by the ecosystem will be lost. Therefore, sustainability should be adopted as a way towards the conservation of the wetland ecosystem.

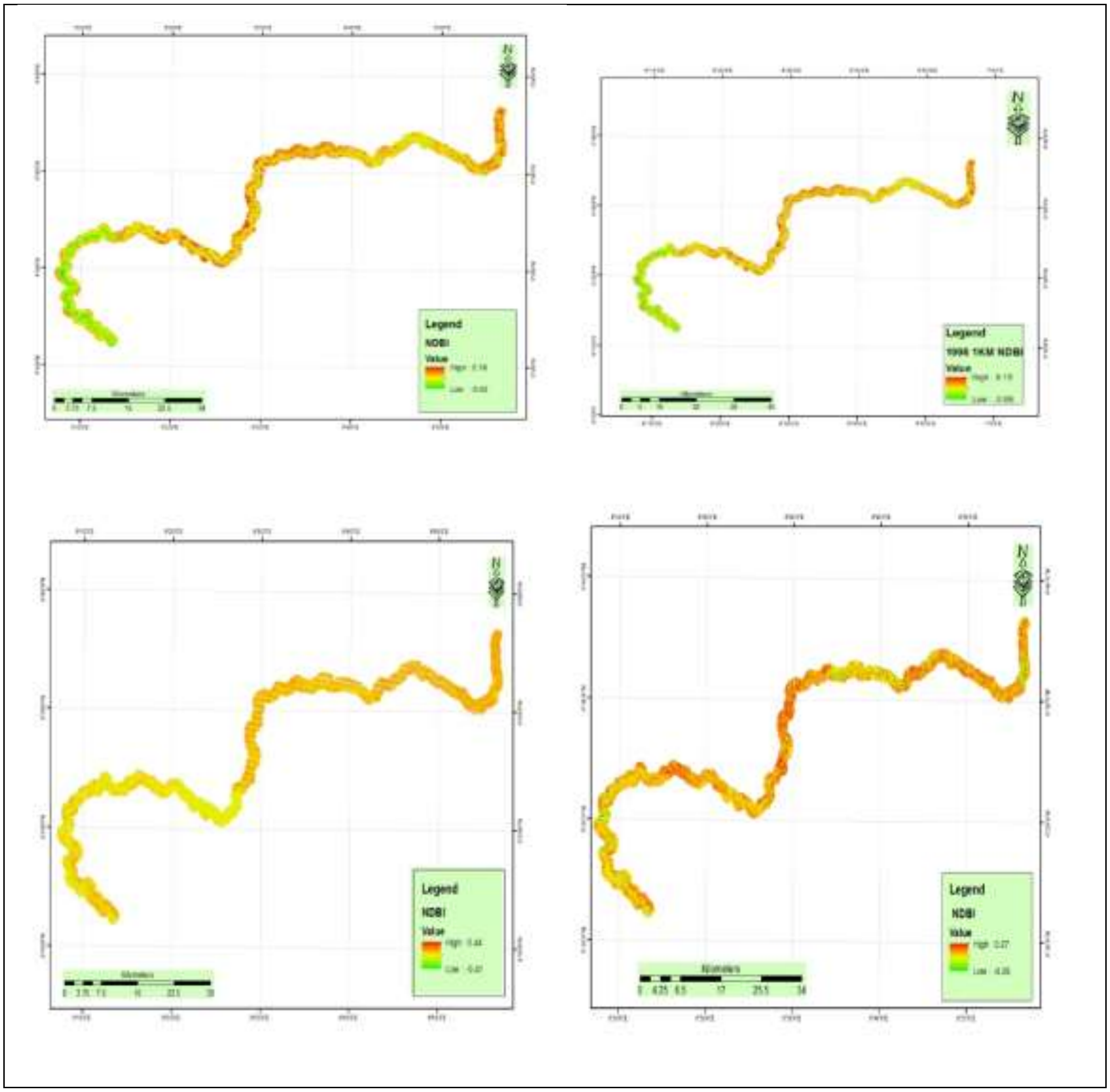


Figure 4.25: Normalized Difference Build-up Index map of Chanchaga1km (1988, 1998, 2008 & 2018)

Source: Authors' Data Analysis, 2018.

4.2.1.4 Summary of the effects of human activities on wetlands through urbanization

The researcher emphasizes that the discussion exposed in this work could be helpful to provide a better understanding of the capabilities and limitations of built-up indices as they relate encroachment to the wetland ecosystem. It is concluded that NDBI is much more effective and advantageous in mapping general built-up areas than the maximum likelihood method. It can serve as a worthwhile alternative for quickly mapping urban land. Build-up Index is the index for analysis of urban patterns using NDBI. The built-up index is the binary image with only a higher positive value indicates built-up and barren. Thus, it allows built-up (BU) to map the built-up area automatically.

Wetlands are land transitional between terrestrial and aquatic systems where the water level is usually at or near the land's surface is covered by shallow water. Each wetland comprises many physical, biological and chemical components such as soils, water, plants and animal species, and nutrients. This wetland ecosystem structure (tangible items) yields benefits, which are of direct use value to humans. Many tropical wetlands are being directly exploited to support human livelihoods, as in wetlands within the study areas. Here people are presently involved in the cultivation of the wetlands for food crops production, some are fishing from the rich wetlands, and others are into harvesting plants for medicinal purposes.

Furthermore, globally, wetland ecosystems are under pressure from rapidly increasing urban populations in wetland areas. Possible effects of urbanization on wetland hydrology and geomorphology (modified from Lee *et al.*, 2006) are summarized below, which includes:

(a) Hydrology

i. Decreased surface storage of storm water results in increased surface run-off (resulting in increased surface water input to wetland)
ii. Increased storm water discharge relative to base-flow discharge results in increased erosive force within stream channels, which results in increased sediment inputs to recipient coastal systems
iii. Changes in water quality (increased turbidity, increased nutrients, metals, organic pollutants, decreased oxygen concentration)

iv. Culvert, outfalls replace low-order streams; this results in more variable base-flow and low-flow conditions

v. Decreased groundwater recharge results in decreased groundwater flow, which reduces base flow and may eliminate dry-season stream flow

vi. Increased flood frequency and magnitude result in more scour of wetland surface

vii. An increase in the range of flow rates (low flows are diminished; high flows are augmented) may deprive wetlands of water during dry weather

viii. Greater regulation of flows decreases the magnitude of the spring flush

(b) Geomorphology

i. The decreased sinuosity of wetland/upland edge reduces the amount of ecotone habitat

ii. Decreased sinuosity and river channels result in increased velocity of stream water discharge to receiving wetlands

iii. Alterations in shape and slopes (e.g. convexity) affects water-gathering or waste-disseminating properties

iv. The increased cross-sectional area of stream channels (due to erosional effects of increased flood peak flow) increases erosion along banks

Others are Direct habitat destruction and alteration are two of the main causes of global coastal wetland decline. Urban centres have often developed in estuaries, and today, few of these remain unaffected by human activities and Fragmentation of wetland habitats can also impact the fauna that depends on these ecosystems for habitat and food, particularly those with specific needs

4.3 Simulation Analysis of the Effect of Urbanization on the Wetland Ecosystem for 2030

The effect of urbanization on the wetland ecosystem for the year 2030 in the three locations was analysed to identify the worst-case study area.

4.3.1 Result Validation of the study areas on Classified LULC of 2018 and Simulated LULC of 2018

Figure 4.26 reveals the predicted maps of Bida, Kotangora and Chanchaga of the study areas. Commonly, if the Kappa index is less than or equal to 0.4, the land uses changed greatly and with poor consistency between the two images. If the Kappa index is 0.4–0.75, general consistencies and obvious changes between the two images. Otherwise, there is high consistency between the two images; the Kappa values range from 0 to 1. Values of 0.61–0.80 means substantial, while 0.81–1 means almost perfect (Yousheng *et al.*, 2011; Liping *et al.*, 2018).

The computed Kappa index between the predicted map and the observed map of 2018 is 0.752, 0.684 and 0.663 for Bida, Kontagora and Chanchaga, illustrating that the results are reliable. There was high consistency between the actual classified results and predictive results. The precision for correct predictions is relatively high; therefore, this method was used to predict the results in 2030. The statistics for the predicted map of Bida, Kotangora and Chanchaga is presented in Table 4.11. This agrees with the work of (Olmedo *et al.*, 2015), who carry out a Comparison study of simulation models in terms of quantity and allocation of land change

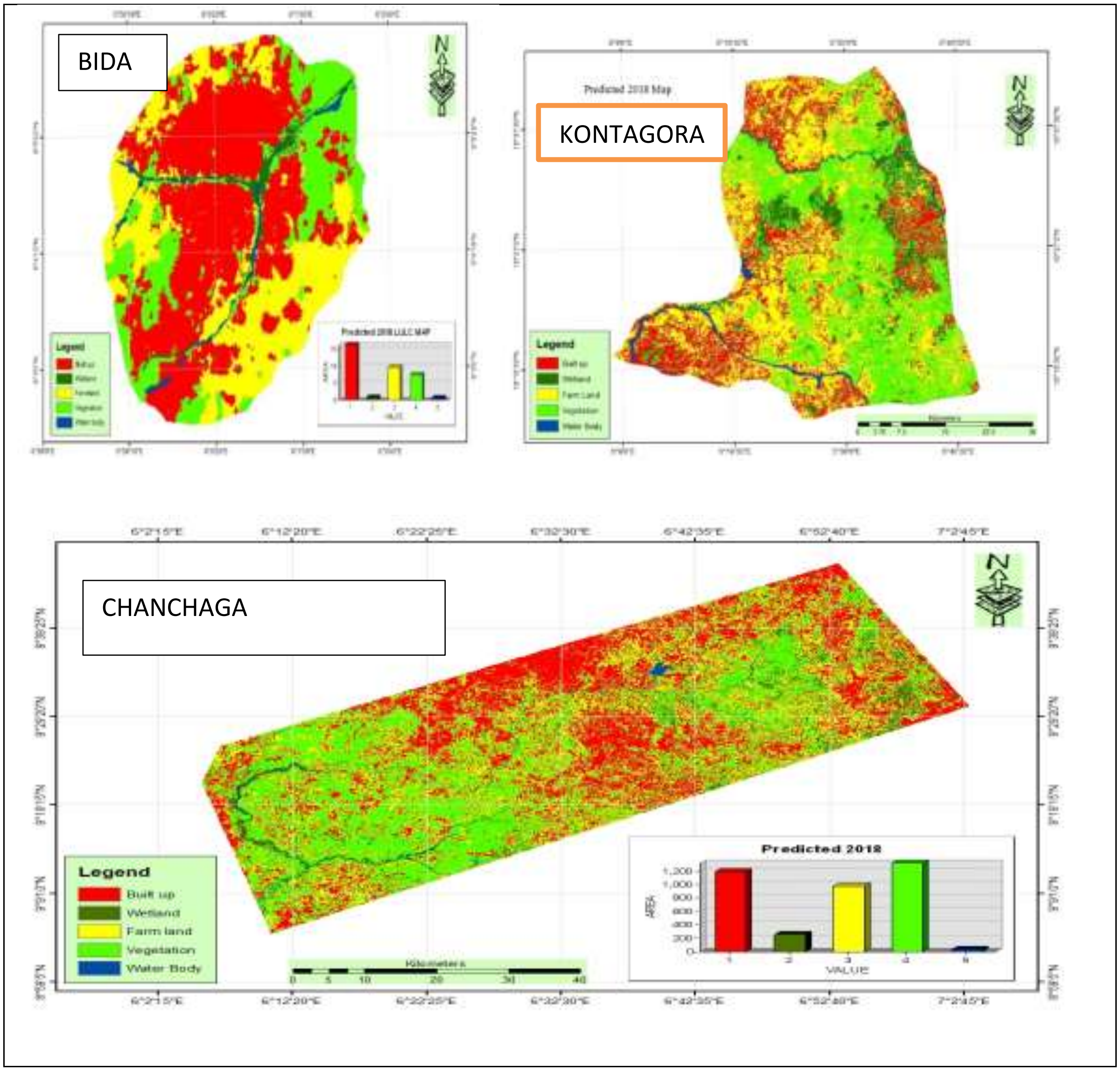


Figure 4.26:Predicted 2018 LULC of Bida, Kotangora and Chanchaga

Table 4. 11 Predicted LULC Distribution of Bida, Kontagora and Chanchaga for 2018

year	Land use and land cover Distribution (Area coverage in Km^2)				
	Build up	Wetland	Farmland	Vegetation	Waterbody
Bida	16.3422	0.7857	9.6219	7.4943	0.594
Kotangora	435.5316	146.2815	759.7503	681.5268	35.1207
Chanchaga	1181.8467	256.0059	973.7082	1314.2007	28.0818

Source: Author's Analysis, 2018

4.3.2 Simulation Analysis of the Effect of Urbanization on the Wetland Ecosystem for 2030 in Kontagora

The simulated land–use map of the study area for the year 2030in Kontagora shows a spontaneous increase in the built-up rates from 489.114 Km^2 (23.76%) in 2018 to 801.1656 (Km^2),representing 39.59% in (2030) of the land-use class category, Indicate an increment of 312.0516(Km^2) representing (15.83%). Thus, the simulation of LULC in the year 2030 clearly shows that the urban area will increase rapidly due to the high population growth at the expense of other LULC classes. This agrees with the work of (Buba *et al.*, 2016), which states that increasing population with rapid settlement growth encroaching into vegetation and agricultural land, making the area vulnerable to the risks of climate change.

Similarly, wetland covering an area of 146.5695Km2 (7.12%) in 2018 will reduce to 103.5396Km^2 (5.12%) by 2030. Also, Farmland representing 775.7793 Km^2 (37.69%) in 2018 will reduce to 393.5592Km^2(35.82%) in (2030) and vegetation representing 612.09 Km^2 (29.74%) in 2018 will also reduce to 393.5592Km^2(19.45%)in (2030) at the expense of built- up. Finally, Waterbody covers 34.8849 Km^2 (1.69%) of the total land area in 2018 and reduces further to 0.522Km^2(0.03%) in 2030 (Figure 4.27).

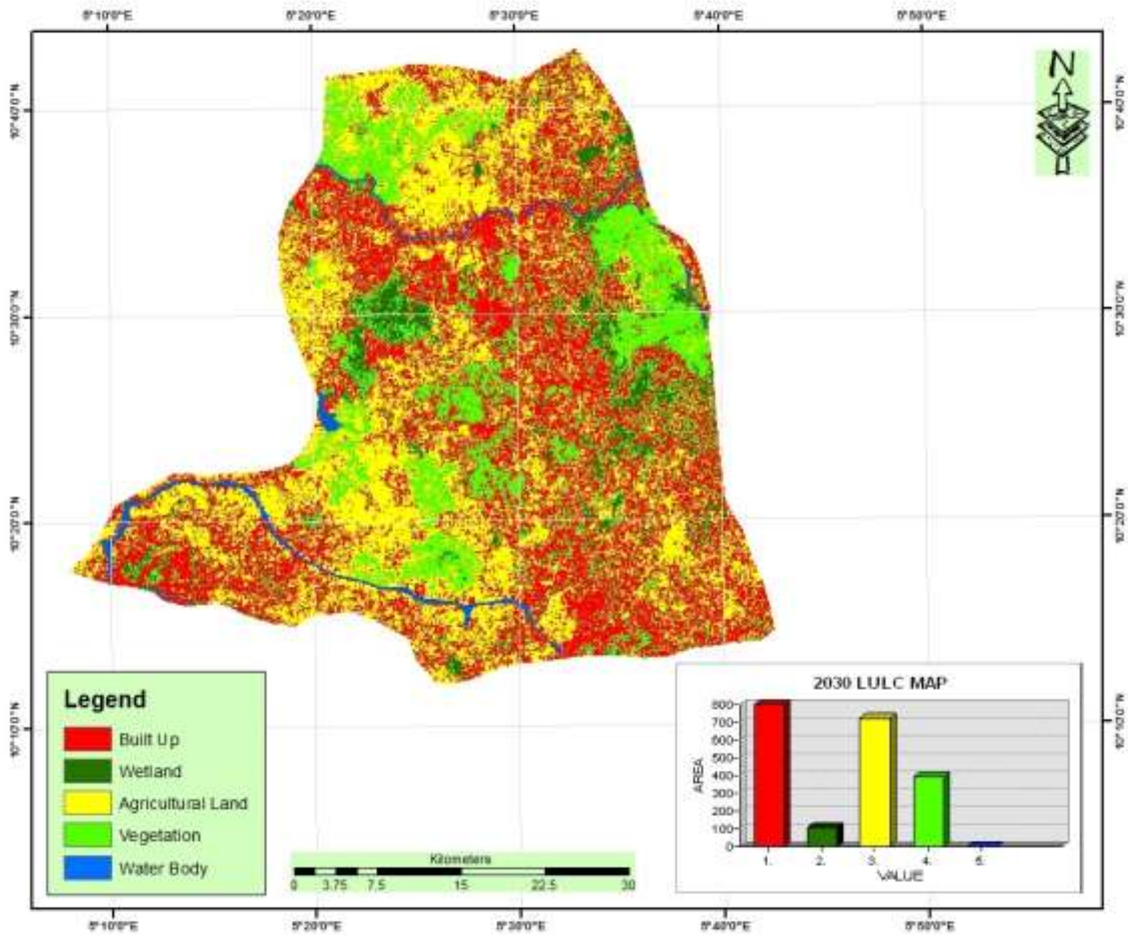


Figure 4.27 Simulated 2030 LULC of Kontagora

4.3.3 Simulation Analysis of the Effect of Urbanization on the Wetland Ecosystem for 2030 in Bida

The simulated land use and land cover map of the study area for the year 2030in Bida revealed a spontaneous increase in the built-up rates from 20.4588 Km2 (58.75%) in 2018 to 25.6617 (Km^2),representing (73.67%) in (2030) the land-use class category, Indicate an increment of 5.2029 (Km^2) representing (14.92%). Thus, the simulation of LULC in the year 2030 clearly shows that the urban area will continue to increase rapidly due to the high population growth in the study area. Since the town is home to many ethnic groups from different parts of the country at the expense of other LULC classes, this agrees with the work of (Buba *et al*., 2016), which states that increasing population with rapid settlement growth encroaching into vegetation and agricultural land, making the area vulnerable to the risks of climate change.

Furthermore, wetland covering an area of 1.9746 Km2 (5.67%) Km^2in 2018 will reduce slightly to 1.161 Km^2 (3.33%) by 2030. Also, Farmland representing 5.5125 Km^2 (15.83%)in 2018 will reduce to 3.5487Km^2(10.19%) in (2030),and vegetation representing6.1317Km^2 (17.61%) 2018 will also reduce to 3.5424Km^2 (10.17%) in (2030) the expense of built-up. Finally, Water body covers will occupy 0.9207 Km^2 (2.64%) of the total land area by 2030 (Figure 4.28).

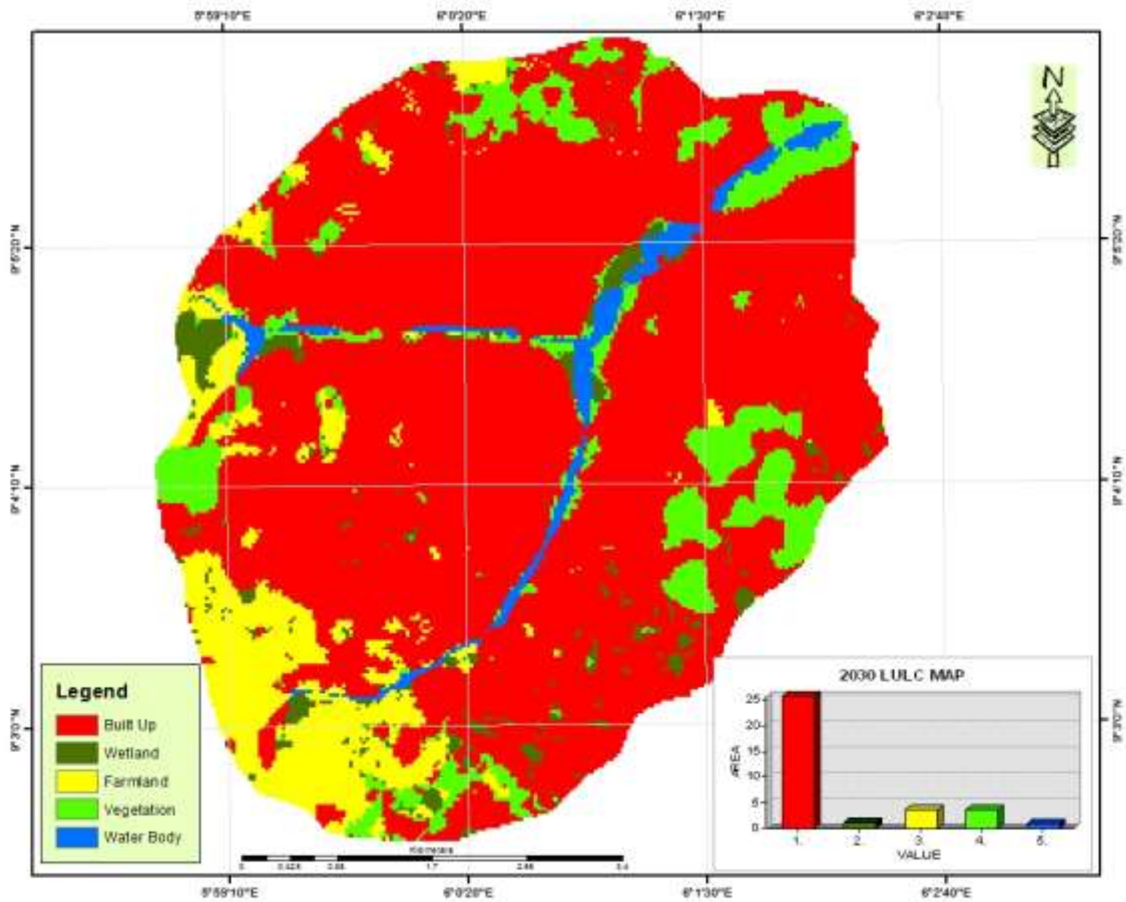


Figure 4.28 Simulated 2030 LULC of Bida

4.3.4 Simulation Analysis of the Effect of Urbanization on the Wetland Ecosystem for 2030 in Chanchaga

The simulated land use and land cover map of the study area for the year 2030in the Chanchaga area indicate high-level incensement in the built-up rates from 1146.758 km² (30.55%)in 2018 to1610.3538km² representing (42.91%) in (2030) of the land-use class category, Indicate an increment of 463.5958km² representing (12.36%). The simulation of LULC in the year 2030 shows that the urban area will continue to increase rapidly due to the high population growth in the study area. Since the town is home to many ethnic groups from different parts of the country at the expense of other LULC classes, this agrees with the work of (Buba *et al.*, 2016), which states that increasing population with rapid settlement growth encroaching into vegetation and agricultural land, making the area vulnerable to climate change.

Additionally, wetland covers an area of 252.1296 km² (6.72%)in 2018 will decrease slightly to 206.2422Km2 (5.49%) by 2030. Also, Farmland representing 1169.972 km² (31.17%) in 2018 will reduce to 801.7686Km2 (21.36%) in (2030) and vegetation representing1157.248 km² (30.83%) 2018 will also reduce to 1109.5785Km2 (29.56%) in (2030) at the expense of built- up. Finally, Waterbody covers will occupy 25.1082Km2 (0.67%) of the total land area by 2030 (Figure 4.28).

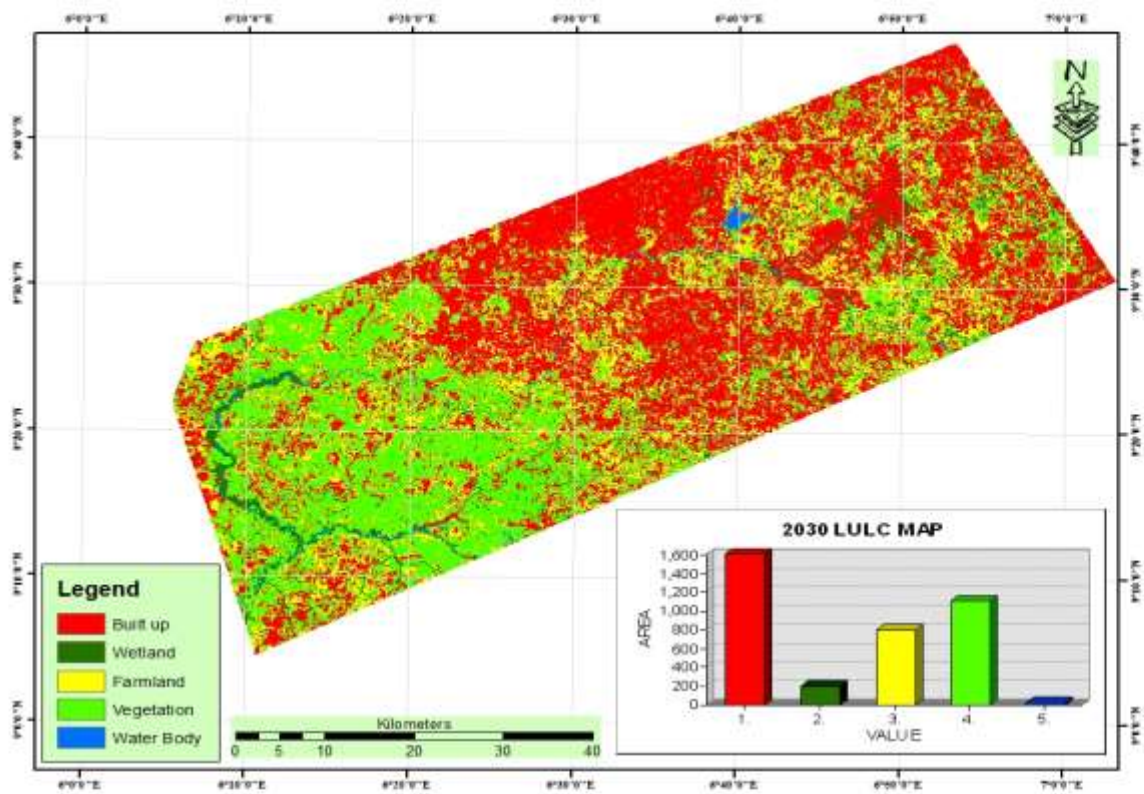
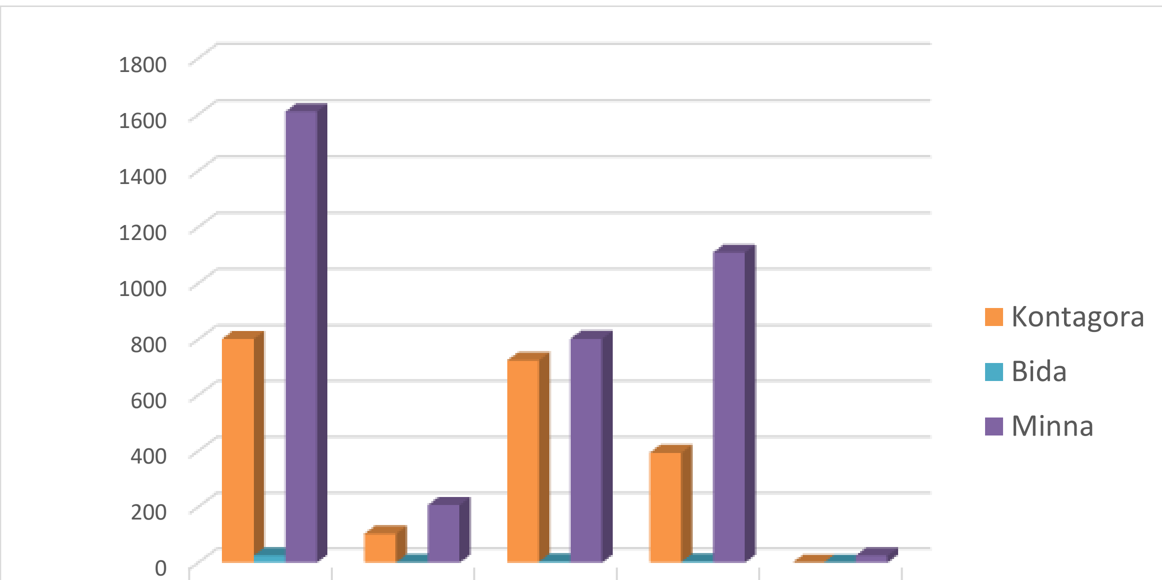


Figure 4.29. Simulated 2030 LULC of Chanchaga

Figure 4.29 and Table 4.11 summarise the simulated LULC distribution statistics of Kontagora, Bida and Minna in kilometres square (Km^2). The result shows that Minna will have the largest built-up area of 1610.3538km² (42.91%) in (2030) because it has the largest area coverage. This is followed by Kontagora 801.1656 (Km^2) 39.59% in (2030), then finally Bida with 25.6617 (Km^2) (73.67%). Similarly, wetland areas will decrease to 206.2422Km2 (5.49%)in Minna, 1.161Km2 (3.33%) in Bida and 103.5396Km2 (5.12%) in Kontagora by 2030; this is attributed to an increase in population size.



	Build up	Wetland	Farmland	Vegetation	Water body
Kontagora	801.1656	103.5396	724.7664	393.5592	0.522
Bida	25.66	1.161	3.55	3.54	0.92
Minna	1610.3538	206.2422	801.7686	1109.5785	25.1082

Figure 4.30:Simulated 2030 LULC of the study areas in km² (Kontagora, Bida, and Chanchaga)

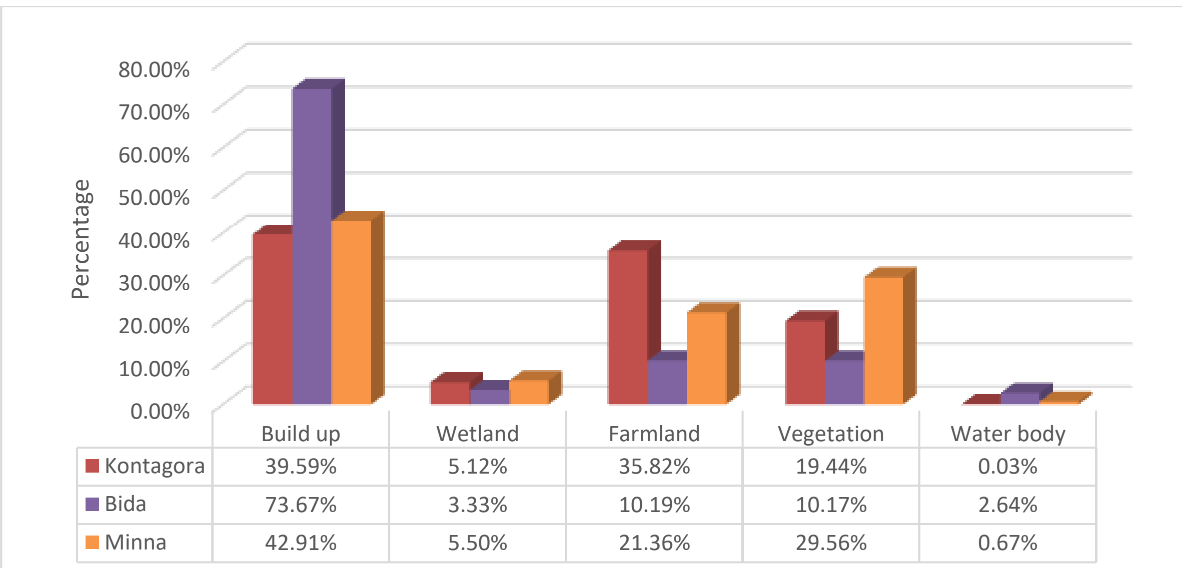
Table 4.12: Simulated 2030 LULC of the study areas in km² (Kontagora, Bida and Minna)

Land Cover Category	Kontagora	Bida	Minna
Build up	801.1656	25.66	1610.3538
Wetland	103.5396	1.161	206.2422
Farmland	724.7664	3.55	801.7686
Vegetation	393.5592	3.54	1109.5785
Water body	0.522	0.92	25.1082

Source: Author's Analysis, 2018

Also, farmland will be higher in Minna with an area of 801.7686Km2(21.36%), 3.5487Km2 (10.19%) at Bida and 393.5592Km2 (35.82%) in Kontagora in (2030). Furthermore, vegetation will be 1109.5785Km2 (29.56%) in Minna, 3.5424Km2 (10.17%) in Bida and 393.5592Km2 (19.45%)in (2030). Finally, water body also continues to decrease starting from Minna with 25.1082Km2 (0.67%), Bida 0.9207Km2 (2.64%) and Kontagora0.522Km2 (0.03%) in 2030. It can be concluded that there will continue to be changed in the land use categories across the study areas, most especially the human settlement, due to escalating population. Figure 4.30 was used to illustrate and convey the information more clearly on the trend of the land use category across the three (3) study locations.

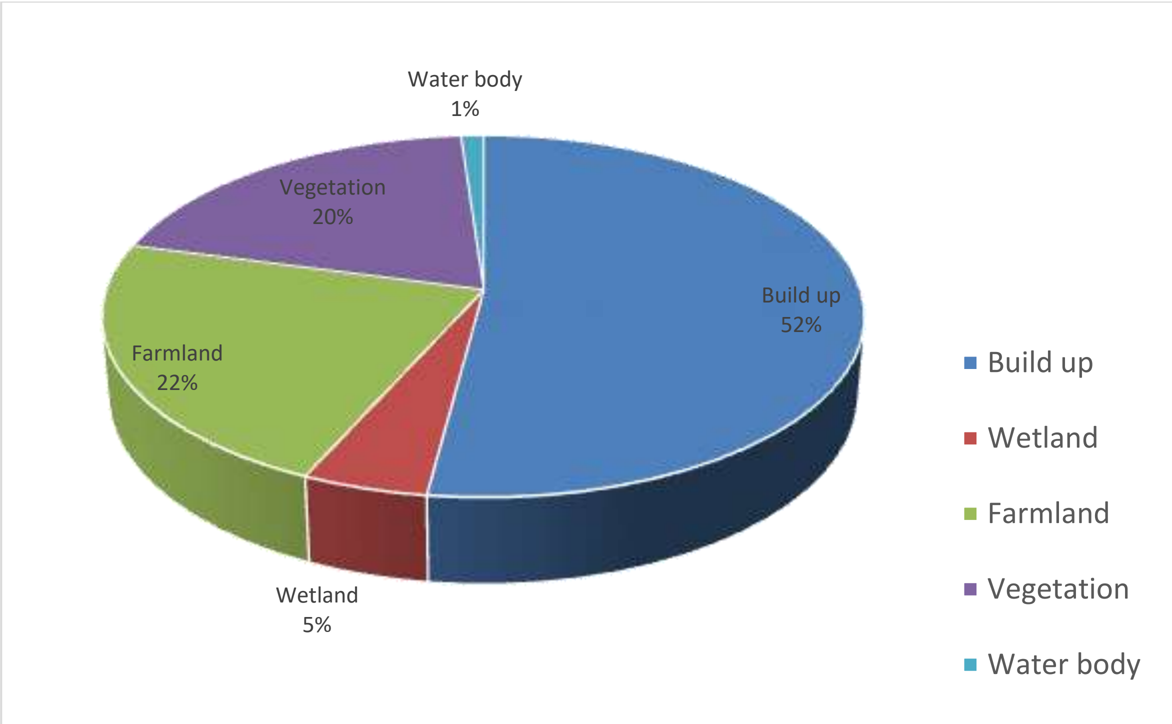
Similarly, Figure 4.30 reveals the percentages change of LULC category across the study areas that will occur over space and time by 2030. These maps show a clear pattern of increased urban expansion, prolonging from urban centres to adjoining non-built up areas along major transportation corridors. The highest rate of urban growth will be observed in Bida, in which the built-up area will be increased more than twice 73.67 % within 12 years, and wetland areas will reduce further to 3.33%as shown in figure 4.31. Minna follows this with 42.91% in built-up and 5.50% in wetland areas. In addition, Kontagora will have the lowest built-up area covering only 39.59%, whereas wetland will be reduced to 5.12%. The results imply that urbanization will be more in Bida than in Minna and Kontagora; this can be attributed to the fact that right from the 1980s, urbanization was much in Bida than in the other areas.



4.31: (%) of Simulated 2030 LULC of the study areas in km² (Kontagora, Bida, and Chanchaga)

Source: Author’s Analysis, 2018

Furthermore, 4.31 reveals the mean percentage change of the three (3) locations, and the chart reveals that urbanisation represented by an increase in built-up areas around the wetlands with 52% and water bodies affect the wetlands by depleting them to 1% and 5%, respectively.



4.32: Mean Percentage distribution of Simulated 2030 LULC of the study areas (Kontagora, Bida, and Chanchaga)

The continuous decrease in wetland and increase in built maybe because wetlands have provided them access to a fresh and affordable vegetable that is readily available provides employment opportunities to the unemployed people, thus improving their economic status in the communities and means of alleviating poverty in the respective areas which have resulted to increased encroachment of the wetland ecosystem. The employment opportunities are shown on plates II, III, IV and V


Plate IV: Agricultural Activities on Landzun Wetland Area

Plate V: Urban Encroachment on Landzun Wetland Area

Plate VI: Urban Encroachment on Landzun Wetland Area

Plate VII: Agricultural Activities on Kontagora Wetland Area

4.4 Potential of land Use Planning For Effective Wetland Ecosystem Management in Chanchaga-Minna, Landzun-Bida and Kontagora

A total of three hundred and fifty (350) questionnaires were administered in three wetlands that constitute the study area. A total of 335, representing 95.7%, were returned. Bida has the highest response percentage (96.7%), while Chanchaga and Kotangora recorded 96% and 94% responses, respectively (Table 4.13).

Table 4.13 Field survey responses on land use planning for effective wetland management

Wetland areas	Number of questionnaires administered	Number of questionnaires returned	Response rate (%)
Chanchaga	100	96	96
Kotangora	100	94	94
Bida	150	145	96.7
Total	**350**	**335**	**95.7**

Source: Field survey, 2019

b) **Demographic and other socio-economic characteristics of the population.**

Socio-economic characteristics of the population including, gender, education, occupation, duration of stay, and age, play an important role in how the population perceived the impact of urbanization on land use and land cover dynamics of wetland ecosystem in the study area.

Table 4. 14: Demographic characteristics of the populations

Gender	**Frequencies**	**Percentage (%)**
Male	213	63.58
Female	122	36.42
Total	335	100
Educational Level		
No formal Edu	140	41.79
Primary School	93	27.76
Secondary school	37	11.04
Tertiary	65	19.40
Total	335	100
Occupation		
Civil servant	45	13.43
Farmer	128	38.21
Business	95	28.36
Students	67	20
Total	335	100
Duration of stay at the wetland		
1 – 5 years	36	10.75
6 – 10	123	36.72
Above 10 Years	176	52.54
Total	335	100
Age		
Less than 18 Years	33	9.85
18 – 30 Years	50	14.93
31 – 40 Years	94	28.06
More than 40 Years	158	47.16
Total	335	100

Source: Authors Field work 2019

The analysis of demographic characteristics of the population of the study areas showed that there are more males (63.58%) than females (36.42%) were interviewed in the three study locations (Bida, Kotangora and Chanchaga). This can be deduced from the distribution of gender population in the state, which includes that there are more males (2,032,725) to females (1,917 524) in Niger State (NPC, 2006).

On the distribution of educational qualifications, a reasonable number of the population across the study area (41.79%) had no formal education and only (11.04%) have formal education. The implication of this high percentage of the population not having a formal education is that the wetland ecosystem will not be used sustainably.

Similarly, most of the populations (47.16%) were within the age range of 40 years and above in all three locations, while the least is less than 18 years (9.85%). Also, most of the populations across the study locations are farmers (38.21%), while the least is a civil servant (13.43%). This means that most of the population engage in one agricultural activity or the other in the areas because of the usefulness of the wetland in food products, especially for household consumption.

Additionally, about (52.54%) had been living in the study locations for more than 10 years, and this indicates that most of the populations have lived long enough in the study locations to have noted the changing wetland pattern. The statistics are presented in Table 4.13.

c) The Benefits of wetland use to the population of the study locations

The various benefits of wetland ecosystem were analysed, and the results are presented inFigure4.32; about 91% of the populations across the study locations strongly agreed to the fact that wetland ecosystem is of great benefits to them because of the immense benefits such as fertile land for farming and as a source to enormous resource potential while 9% disagree to the benefits of wetland in their community (figure 4.33)

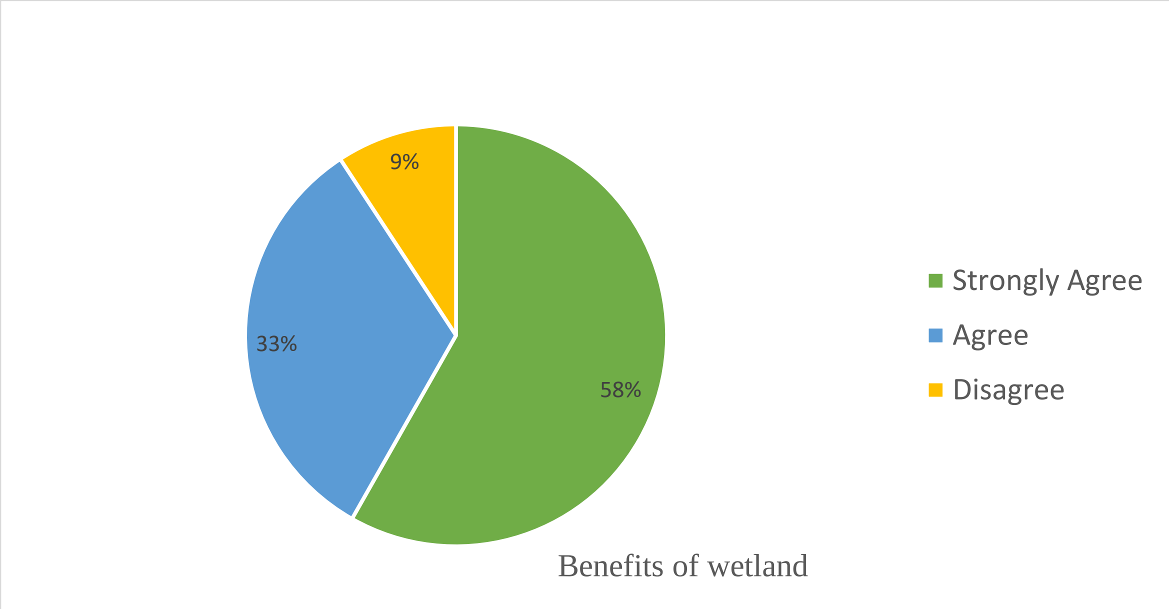


Figure 4.33 Analyzed views of wetland use in the study areas.

Similarly, most of the populations (49.55%) across the study locations say that control of flooding and soil erosion is the most valued benefit of wetland in their areas, while 29.55% and 20.89% are averaged valued and least valued, respectively.

In addition, the majority of the populations 36.42%, 61.49%, 59.10%, 20.29%, 73.43%, 41.19%, 40.29%, 25.37%, 32.84%, 67.14%, 72.84%, and 44.18%, agrees that the most valued benefits they derived are Discharge and charge of water, Habitat of biodiversity, Effective ecosystems for carbon storage, Water Purification and Nutrient retention, Source of agricultural produce, fish, building materials, fuel wood, wildlife products), Reliable source of water for domestic usage and irrigation, Source of income and employment (38.81%), Source of charcoals/timber/papyrus/Firewood, Good for Tourism and Recreation attraction, Provide forage for livestock (20.29%), Ideal and extra land for farming and Extra land for human settlement respectively as indicated on Table 4.15

Table 4.15: Benefits of wetland ecosystem on the study areas

S/N	QUESTION	MV	%	AV	%	LV	%	% Total	Total
3	Control of flooding soil erosion	166	49.55	99	29.55	70	20.89	100	335
4	Discharge and charge of water	122	36.42	142	42.39	71	21.19	100	335
5	Habitat of biodiversity	206	61.49	96	28.66	33	9.85	100	335
6	Effective ecosystems for carbon storage	198	59.10	101	30.15	36	10.75	100	335
7	Water Purification and Nutrient retention	68	20.29	231	68.96	36	10.75	100	335
8	Source of agricultural produce, fish, building materials, fuelwood, wildlife products)	246	73.43	57	17.01	32	9.55	100	335
9	Reliable source of water for domestic usage and irrigation	138	41.19	129	38.51	68	20.30	100	335
10	Source of income and employment	135	40.29	130	38.81	70	20.89	100	335
12	Source of charcoals/timber/papyrus/Firewood	85	25.37	167	49.85	73	21.79	100	335
13	Good for Tourism and Recreation attraction	110	32.84	134	40	91	27.16	100	335
14	Provide forage for livestock	225	67.14	68	20.29	41	12.24	100	335
15	Ideal and extra land for farming	244	72.84	75	22.39	16	4.75	100	335
16	Extra land for human settlement	148	44.18	90	26.87	97	28.96	100	335

Hence, the benefits of wetland to the population of the study areas can never be overemphasized, as shown in Table 4.15.

On the population encroachment on the wetlands of the study areas and subsequent extraction of its valuable resources, 61%of the inhabitant of the wetland areas attested to the fact that the encroachment through urbanization process and farming and extractions of building materials resulted in continuous degradation of the wetland s of the study areas. This significantly present day to day management challenges

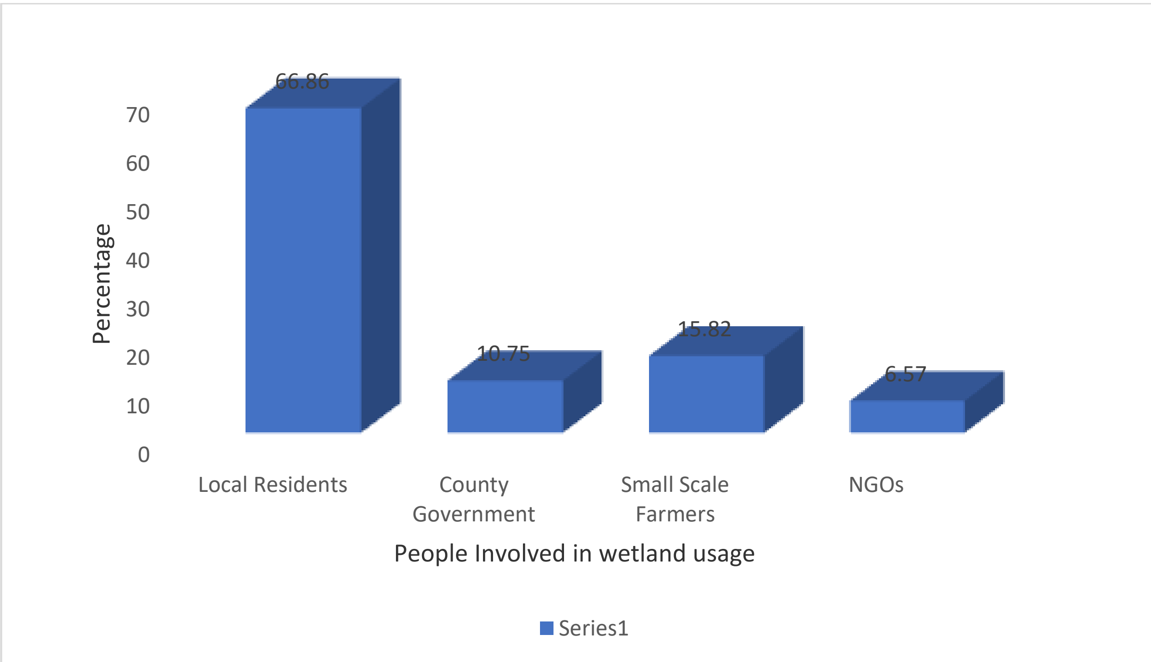


Figure 4. 34 Percentage distribution of stakeholders in wetland usage.

d) Human activities on wetland degradation across the study areas

Based on the assessment of human activities on the wetland of the study areas, 88.30% of the population strongly agreed that unchecked over-exploitation and human activities have led to wetland degradation, and 12% disagreed, as shown in Figure 4.35. some of the human activities are indicated on plates V, VI and VII

Plate VIII: Irrigation farming activitieson Chanchaga – Minna wetland

Plate IX: Farming activities on Chanchaga – Minna wetland

Plate X: Block industry activities on the wetland area

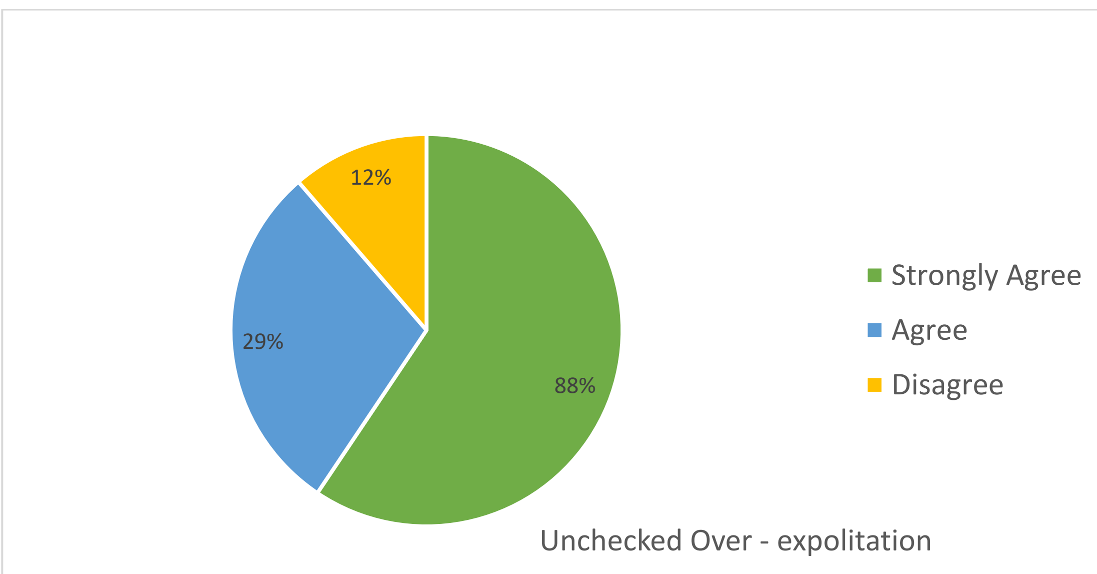


Figure 4.35: Population response on the effect of human activities on Wetland in the study areas

Table 4.16: Identified human activities on the wetland of the study areas.

S/N	QUESTION	MSD	%	AD	%	LSD	%	Total (%)	Total
1	continuous built up on the wetland	206	61.49	65	19.40	64	19.10	100	335
2	Deforestation and trees harvesting for firewood, charcoal and timber	156	46.57	54	16.12	125	37.31	100	335
3	Agricultural encroachment e.g. flower growing and subsistence farming	267	79.70	49	14.63	19	5.67	100	335
4	Over-extraction of water for household and irrigation	149	44.48	117	34.93	69	20.59	100	335
5	Vegetation over-harvesting	106	31.64	186	55.52	43	12.84	100	335

where MSD represent (the Most Serious damage), AD(Average damage)LSD the (least serious damage)

Source: Authors Analysis, 2018

e) **Analysis of Wetland Conservation and Sustainable Utilization**

Regarding wetland conservation and sustainable utilization across the study areas, results indicate that 70% agree that wetland resources are not being used sustainably; also, 29% agree that it has been utilized sustainably while 1% says it is highly sustainable.

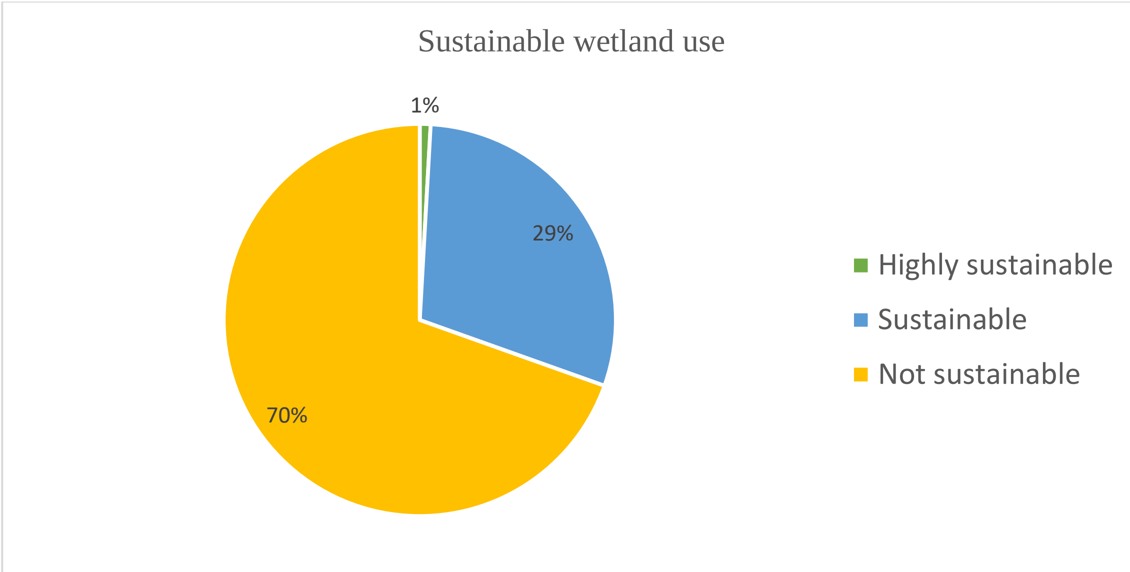


Figure 4.36: Distribution patterns of sustainable wetland use in the study areas

In addition, based on support, protection and conservation measures that allow maintenance of wetlands and their functions. Figure 4.37 shows that 51% of the respondents strongly agree to support, protect and conserve that allow maintenance of wetlands and their functions. 37% agree to the support, protection and conservation measures that allow maintenance of wetlands and their functions across the study area, the remaining 12% of the population disagrees that conservation measures may be attributed to their low level of understanding of the importance of conservation, they feel that they will be deprived of their means of livelihood.

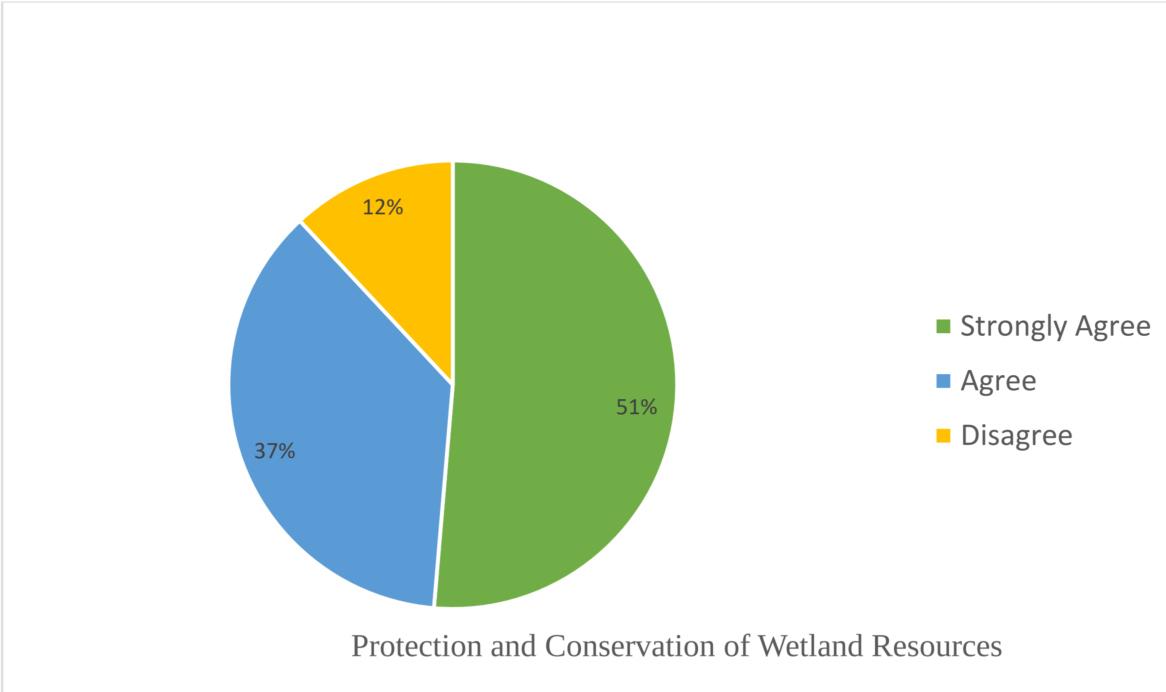


Figure 4.37 Percentage distribution of protection and conservation of wetland resources in the study areas.

Figure 4.38 is the distribution of ways to assist in wetland conservation. The assistance received in the conservation efforts indicated that 40% were willing to practice sustainable utilization of wetland at individual and communal levels, whereas 38% believes that educating and creating awareness in the community will also help in conservation efforts and finally, 7% and 14.63% believe they will offer financial support, technical and professional expertise respectively.

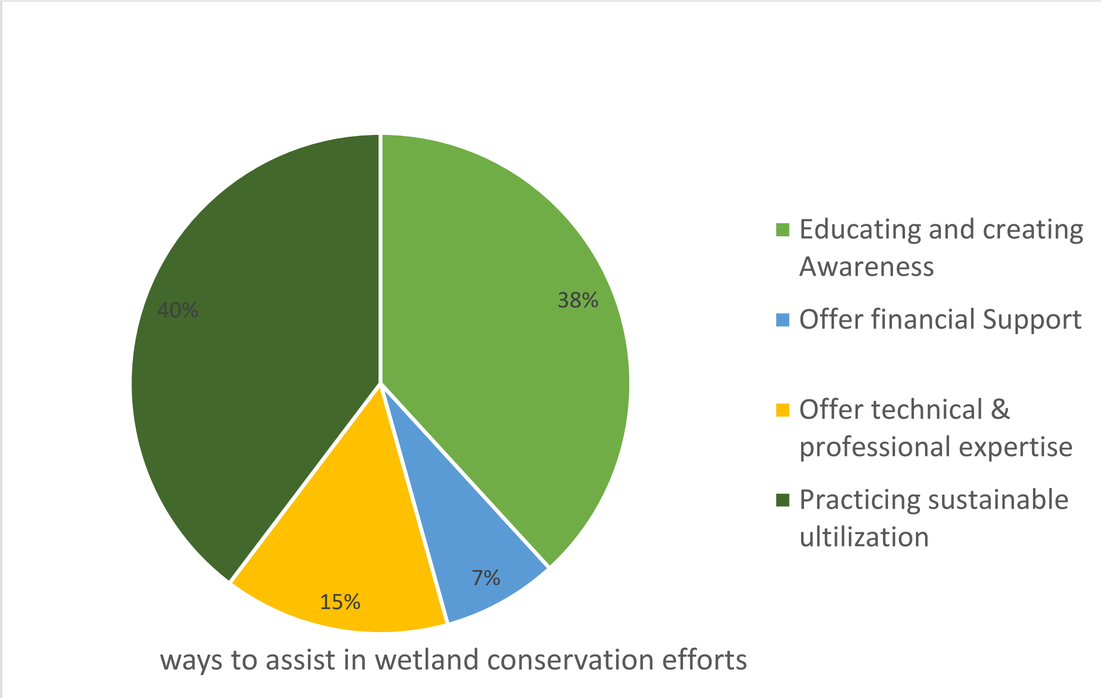


Figure 4.38 Ways to assist in wetland conservation efforts

Source: Authors Analysis, 2018

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study analysed spatial and temporal changes in the areal extent of the existing wetlands in the study area, the effect of human urbanization on wetland ecosystem in the study area, simulate the effects of urbanization on wetland ecosystem to the year 2030 in the study area and examine the potential of land-use planning for an effective wetland ecosystem in the study area. Photography and Landsat imageries were used for data analysis. Based on the findings, the study concluded that significant Spatio-temporal changes in wetland land use and the land cover have occurred during the study period. The changes were attributed to population increase, farmland cultivation, and built-up areas between 2008 and 2018. Though disparities in area coverage and percentage distribution of the various land-use types and wetland depletion existed within and between the study locations, the general picture is that wetlands in the study locations are under severe and continuous threat from urbanization. The study also concluded that more rapid urbanization took place in the study area between2008 to 2018. These had resulted in direct habitat loss, suspended solids additions, hydrologic changes, altered water quality, increase runoff volumes, diminished infiltration, reduce stream base flows and groundwater supplies, prolonging dry periods, to mention just a few. Based on the predicted future results on the wetlands, the study concluded that Minna would have the largest built-up area of 1610.3538km² (42.91%), followed by Kontagora 801.1656 (Km^2) 39.59% and Bida 25.6617 (Km^2) (73.67%) in 2030. The most significant changes in Minna are not unconnected to the state capital. Similarly, it is concluded that wetland areas would decrease to 206.2422Km2 (5.49%) in Minna, 1.161km2 (3.33%) in Bida and 103.5396Km2 (5.12%) in Kontogora by 2030.

5.2 Recommendations

Based on the findings from the research, the following recommendations are made.

a) There is a need for continuous monitoring by regulatory authorities to ensure compliance with extant laws on wetland ecosystem management.

b) As Wetlands continue to decrease, built-up areas are on the increase over the study period due to population pressure, which affects the wetland negatively. Therefore to safeguard the wetland, there should be enforcement of sustainable land-use policies and alternative income sources for the population that rely on the wetland as a means of livelihood.

c) Human activities (both individuals and government) that degrade wetlands should be reduced, while efforts should be on those activities that encourage wetland conservation and preservation. Also, the focus should be shifted from the immediate benefits derived from conversion to future/sustainable benefits derivable from proper wetland management.

d) Adopt the Land Cover modeler (LCM) to predict further the impact of current land-use changes in the wetland and surrounding areas.

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