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An Assessment of the Environmental Impacts of Land Use Dynamics in Eleme, Rivers State, Nigeria

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Abstract

Eleme has a total area of 138km^2 out of which the Federal Government of Nigeria compulsorily acquired an estimated area of 59.34km^2 for industrial purposes excluding acquisitions by the Rivers State Government. Using the combined technologies of Geographic Information Systems (GIS), Remote Sensing (RS) and Demography techniques as its methodology, this paper examines the environmental impacts of land use dynamics in Eleme between 1986 and 2019. The study reveals that between 1986 and 2019, Built-up area and Farmland increased by 72.67 and 12.77 percent respectively, while light and thick vegetation recorded a decrease of -6.92 and -61.64 percent respectively. Water body equally experienced a decline. Also, between 2006 and 2015 covering a period of 9 years, Built-up area further increased by 53 percent with an annual growth rate of 2.32 km^2 gaining more land area to the detriment of other land uses. Built-up area has an annual growth rate of 2.32km^2 and is expected to increase from 18.67km^2 in 2006 to 41.87km^2 in 2016 and 48.83km^2 in 2019. The observed Land use/Land cover dynamics is derived by the demographic characteristics of the Study area. It is evident from the findings of this study that the carrying capacity of Eleme ecosystem is under threat due to the current lands consumption rates. We therefore recommend that all relevant stakeholders and the local authorities to take steps such as aggressive trees planting, use of appropriate farming techniques, proper development control measures, proper wastes management strategies and regimes, an amendment to the Land Use Act of 1978 to check the excessive acquisitions of lands by governments at all levels, and other measures that would safeguard the environment and reduce the rate of natural resources depletion in Eleme.

Key Words: *Land use, environmental impacts, assessment, Eleme, dynamics, land cover, land consumption rate.*

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I. Introduction

Eleme is an area with great economic fortunes and fixed boundary, beset by devastating environmental pollution (groundwater, streams, rivers, land, among others) as identified in the United Nations Environment Programme Report on Environmental Assessment of Ogoniland[36], and rapid population growth occasioned by high level immigrations into the area for greener pastures. It has become expedient to further investigate the environmental impacts and consequences of land use dynamics in the area using the combine technologies of Geographic Information System (GIS) and Remote Sensing (RS), and possibly adducing solutions to these problems as well as sustainable land use practices or alternatives that will guarantee that the carrying capacity of the environment is not exceeded.

Also worrisome about the situation in Eleme is the pressure on food supply, waste generation and disposal, available energy and raw materials; and the problem of rapid urbanization occasioned by government acquisitions of land for establishment and expansion of oil and gas operations and its accompanying influx of people into the area for greener pastures.

From Table 1 below, the area acquired by the Federal Government (59.34 km^2) combined with the area acquired by the Rivers State Government (not determined yet) and that inhabited by Eleme towns/communities indicate that there is enormous pressure on land use in Eleme which has serious impacts on the carrying capacity of Eleme natural environment, hence the justification for this study.

Table 1: Area of Land Acquired by Federal Government in Eleme

S/N	**Name of Company**	**Location**	**Year of Acquisition**	**Compensation Paid**	**Area Acquired**		
					Acres	Km^2	Hectres
1	First Port Harcourt Refinery	Alesa	1963	£15,275,12.10d	305.6	1.24	
2	Federal Lighter Terminal & Naval College	Onne	1974	N500 per acre	1,707	6.91	
3	Federal Ocean Terminal	Onne	1980	N4.2 million		25.38	2,558.173
4	National Fertilizer Company of Nigeria (NAFCON)	Onne	1983	Not available	-	-	-
5	Second Port Harcourt Refinery	Alesa	1984	Not available	199.834	0.81	
6	Eleme Petrochemicals Company Ltd	Akpajo, Aleto, Agbonchia	1984	N12,598,804		9.00	
7	Onne Oil & Gas Free Zone	Onne	1996	Not available		16.00	
Total						**59.34**	

***Source**: Ngofa, (2006)*

1.1 The Study Area

Location

Eleme Local Government Area is one of the 23 Local Government Areas that make up the present Rivers State of Nigeria. Eleme is located between longitude 7^0 and 7^0 15′ (seven degrees and seven degrees fifteen minutes) East of the Meridian and latitudes 4^0 60′ and 4^0 35′ (four degrees sixty minutes and four degrees and thirty-five minutes) North of the Equator. The total area of Eleme is about 138 square kilometers (km^2) as collaborated by Rivers State Government official records and the author's field report. Eleme is bordered on the north by Obio/Akpor and Oyigbo Local Government Areas, on the east by Tai Local Government Area, on the south by Ogu/Bolo and Okrika Local Government Areas as shown in Figure 1 below.

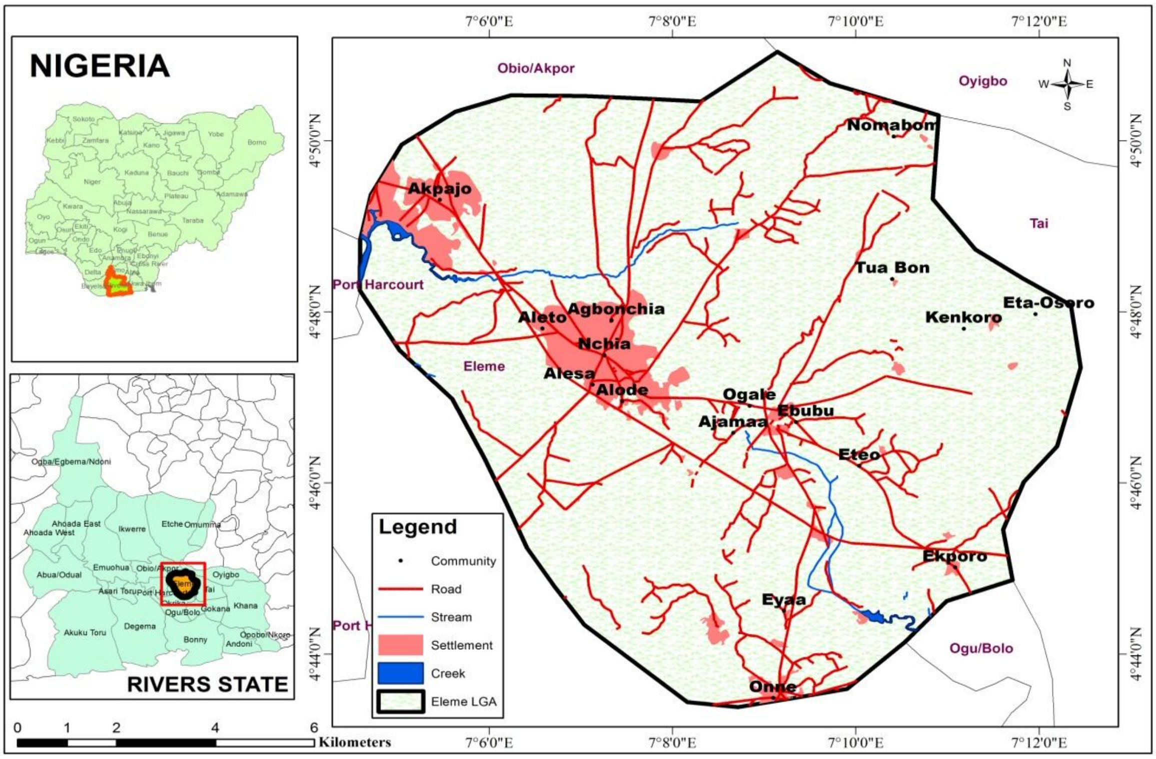


Figure 1: Map of the Study Area (Eleme)

Occupation

The major occupation of Eleme people from ancient times has remained farming and the primary crops are yams, cocoyams, cassava, sugar cane, pumpkin among others. Farmlands are usually in large blocks that are communally cultivated each year through ownership of properly demarcated sections are vested in each family. The yams are carefully staked, the cassava inter-planted during the months of May and June. There are species of yams that are regarded exclusively for women and these are called Okako, Mkpanyi, Ekororkortor, Eburale, Ngulor and Ochun. They are usually planted separately in the strip of farm called Okaelor. Because the block of farms for each yam is located in one section, it is the tradition that no farm work is carried out on the day locally called Obon, or any day that a child or adult is being buried.

Political Administration

After several petitions, delegations and protestations for the granting of administrative autonomy to Eleme, the Federal Government under General SaniAbacha announced on 4th December, 1996, the separation of Eleme and Tai into their respective Local Government Councils. Eleme is an administrative subdivision of Rivers State, Nigeria, located east of the Port Harcourt Local Government Area, it is in the greater Port Harcourt metropolis. The name of its headquarters was changed from Nchia to Ogale by the Legislative Council during the Chairmanship of HonourableOlakaNwogu in 1992. The administrative offices have always being located in Ogale, believed to be the first town of Eleme. Eleme has 10 political wards with each of the major towns (Akpajo, Aleto, Alesa, Agbonchia, Ogale, Alode, Ebubu, Onne, Eteo, and Ekporo) serving as ward each.

Traditional Administration

Eleme is a Kingdom and the head of the Kingdom is known as The Oneh-Eh-Eleme (The Majesty of Eleme). Beneath him are the paramount rulers of each of the two major groups of towns Oneh Eh Nchia (Chief of Nchia) and Oneh Eh Odido (Chief of Odido). Each Nchia and Odido consists of towns which are further divided into small communities (and then further into areas of the community). The traditional ruler of each town is known as Oneh Eh Eta (Town Chief).

Eleme Local Government Area occupies the western end of Ogoniland. It has 10 clans within two administrative political blocs or units: the Nchia bloc with six clans (Akpajo, Aleto, Alesa, Alode, Ogale and Agbonchia) and the Odido bloc with four clans (Onne, Ebubu, Eteo and Ekporo). Each clan has numerous sub-communities; the Ebubu clan for example includes the Ejamah, Ochani, Obollo, Egbalor and Agbeta communities.

Population

The population growth of Eleme is rapid and characterized by immigration rates by settlers seeking greener pasture because of the level of industrialization in the area. In 1937 the population of Eleme was 2,528 persons; 80,715 persons in 1991 and became 190,194 by the 2006 census.

Oil and Gas

According to UNEP[36] the oilfields in Eleme LGA, which encompass locations in Ebubu (Ejamah, Agbeta, Obollo, Egbalor), Ogale (Ajioepuori, Nsisioken, Obajeaken) and Onne (Ekara), were discovered in October 1956. Oil from operations in Eleme was included in the first shipment of 22,000 barrels of crude oil exported from Nigeria to Europe in 1958. The communities of Eleme host several major national and international establishments, for example, Eleme's main river is the ImuNgololo, along which the Nigerian Naval College is based.

Geology and Vegetation

Eleme's aquifers are a crucial resource upon which the region's entire population depends for drinking water. The protection of these aquifers is therefore vital. These aquifers are very shallow, with the top-most groundwater levels occurring anywhere between close to the surface and a depth of 10 meters. To tap the aquifers, Eleme communities typically construct open, hand-dug wells about 60 cm in diameter and water is abstracted either manually or with pumps. In some areas affected by localized pollution of water closer to the surface, wells can be up to 50 meters deep. In such cases, immersible pumps are used to draw water. Water levels in these aquifers are highly seasonal [36].

The coastal area of Eleme comprises three vegetation zones: (i) beach ridge zone, (ii) saltwater zone and (iii) freshwater zone. The beach ridge zone is vegetated by mangroves on the tidal flats and by swamp trees, palms and shrubs on the sandy ridges. The saltwater zone is mainly vegetated by red mangrove (*Rhizophora mangle)*. The coastal plain and freshwater zone is vegetated by forest tree species and oil palm.

Industrial Development

With the discovery of oil in the Niger Delta in the 1958, the Eleme territory has become home to both oil refineries and fertilizer industries, increasing the role of a more industrial economy. About 100 wells are thought to be in use throughout the Eleme territory. The mining of oil has had notable political and environmental effects on the status of the Niger Delta, with pollution from national industries located in Eleme increasing acid rain and reducing soil, water and air qualities. Obviously, Eleme has become an area of much political interest over the last 40 years since oil exploration is estimated to account for around 65 per cent of Nigerian Government budgetary revenue and 95 percent of all foreign exchange earnings (www.odci.gov). Consequent high levels of migration into Eleme territory by other ethnic groups in Nigeria have made a sizable impact on Eleme society. The presence of non-Elemes hoping to find work within the chemical industries has affected the social importance of Eleme cultural identity, raising concerns over the retention of Eleme cultural practices and language use.

The discovery in 1956 of abundant reserves of oil and gas in the area has attracted over one hundred companies that are engaged in the up-stream and down-stream sectors of exploration and exploitation, with the Onne Port Complex serving as the pivot in sub-Saharan Africa.

Eleme has two of Nigeria's four, as of 2005, petroleum refineries and one of Nigeria's busiest sea ports and the largest sea port in West Africa located at Onne, a famous town with numerous industries, Udogu[34].

II. Materials and Methods

Data Source

In order to achieve the objective of the study both primary and secondary data which contain both spatial and non-spatial (attribute) were used. The data used includes:

1. The topographic maps covering the Eleme (Port-Harcourt) Sheet number 329 at a scale of 1:50,000 sourced from the office of Survey General.
2. Multi-temporal Landsat satellite imageries of different year intervals acquired from 1986, 2006, and 2015.
3. Administrative map of the study area.

The detail and characteristics of the above listed data are shown in Table 2 while the general work flow is shown in Figure 5.

Table 1: Characteristics of Data Used

S/NO	Type	Format	Path/Row	Scale/Resolution	Date Source
1	Topographic	Analogue	Port- Harcourt/329	1:50,000	1974/OSGOF
2	Landsat TM	Digital	P188R57	30m	1986/Glovis
3	Landsat ETM	Digital	P188R57	30m	2006/Glovis
4	Landsat 8	Digital	P188R57	30m	2015/Glovis

Map data

The maps procured for this study include: topographic and administrative maps covering the study Area. These maps were used as ancillary data to aid field work, image classification and the compilation of maps produced in the research work. The Maps were scanned, geo-referenced, and sub-map to area of interest after which they were digitized in order to extract the needed thematic layer into the work geo-database.

Remote Sensing Data

Present and past information on land cover and land use change for the study area was generated from multi-date remotely sensed data which was used to evaluate sprawl. Satellite image from Landsat TM for 1986, ETM for 2006 and Landsat 8 for 2015 were acquired. These image data were used for land cover mapping and change detection/analysis. In addition, SPOT 5 imaginary covering the study area was also used to complement the Landsat image since it has a better spatial resolution of 5m

Data Analysis and Interpretation

Six main methods of data analysis were adopted in the study.

(i) Cluster analysis
(ii) Maximum Likelihood Classification
(iii) Calculation of the Area in hectares of the resulting land cover types for each study year and subsequently comparing the results.
(iv) Overlay Operations
(v) Error matrix and a Kappa analysis
(vi) Land Consumption Rate and Absorption Coefficient

The first two methods above were used for image classification to produce land cover map of the study area. The data were imagery of 1986, 2006 and 2015. Calculation of the Area in square kilometer assisted in identifying the percentage change, trend, and rate of change between the periods of investigation.

Land Cover Classification System

In this research, the FAO land cover classification system (LCCS) was used. Following the data and information acquired from the field, the land cover type of the study was generated. They included

1. Cultivated and Managed Terrestrial Area (Farm/Fallow land): This area refers to areas where the natural vegetative cover have been altered and replaced by other type of vegetative cover by human activities. This class encompasses all vegetative crops that are planted with the intent of harvesting.
2. Natural/Semi Natural Vegetation: natural vegetative areas are defined as areas where the vegetative cover is in balance with biotic and abiotic forces of the biotope. Semi Natural vegetative areas are those not planted by human but are influenced by human actions.
3. Artificial Surface and Associated Areas: this class defined areas that have artificial land cover as a result of human activities, these activities includes construction sites, extraction sites, as a result of mining and excavations and waste disposal waste areas. Bare areas described areas that do not have any artificial influence; these areas are those with very small litter or no vegetative cover at all such as rocks, bare sand and desert.
4. Natural Water Bodies: these are areas that are naturally covered by water, such as streams, lakes, rivers, etc.
5. Built-up areas: these include areas occupied by settlements/towns, companies, and infrastructures.

Development of a Classification Scheme

Based on the prior knowledge of the study area for over 15 years and a brief reconnaissance survey with additional information from previous research in the study area, the classification scheme was developed after FAO Land Cover Classification System (LCCS). They include Built-up area (BA), Farm/fallow land (FL), Water body (WB), Thick Vegetation (VG), and Light Vegetation (LVG) as shown in Table 3.

Table 2: Classification Scheme

Code	Land Cover Categories
FA	Farmland
LV	Light Vegetation
BL	Built-up land
TV	Thick Vegetation
WB	Water bodies

Supervised classification

The supervised classification is an essential tool used for extracting quantitative information from remotely sensed image data [26]. Using this method, the analyst has available, sufficient known pixels to generate representative parameters for each class of interest. This step is called training. Once trained, the classifier is then used to attach labels to all the image pixels according to the trained parameters. The most commonly used supervised classification is Maximum Likelihood Classification (MLC), which assumes that each spectral class can be described by a multivariate normal distribution. Five training sites were identified and further classified into the classes listed in the schema

Change Detection

One of the most common applications of change detection is determining urban land use change and assessing urban sprawl. This would assist urban planners and decision makers to implement sound solution for environmental management. A number of approaches have emerged and applied in various studies to determine the spatial extent of land cover changes. It is also reviewed that different methods of detection produce different change maps [1]. Below are methods applied in this study.

Image Differencing

Image differencing is based on the subtraction of images acquired in two different times. This is performed on a pixel by pixel or band by band level to create the difference image. In the process, the digital number (DN) value of one date for a given band is subtracted from the DN value of the same band of another date [29,30]. Since the analysis is pixel by pixel, raw (unprocessed) input images might not present a good result.

Vegetation Index Differencing

This method is applied to analyze the amount of change in vegetation versus non vegetation by computing Normalized Deference Vegetation Index (NDVI). NDVI is one of the most common vegetation indexing method and is calculated by

NDVI= NIR-RED
-1.0 ………………………~~eqn1~~
NIR+RED

Where NIR is the near infrared band response for a given pixel and RED is the red response

Post Classification Comparison:
This is the most obvious, common and suitable method for land cover change detection. This method requires the comparison of independently classified images T1 and T2, the analyst can produce change map which show a complete matrix of changes [29].

Post-Classification Detection Technique:
Post classification technique is one of the most used and simple approach to detecting changes comparison [3]. A post-classification comparison, which is the most straightforward technique, has been applied in this study. The land cover maps for the years 1986, 2006 and 2015 were first simplified into five classes. The post-classification comparison was then applied by differentiating the corresponding classified maps to generate change maps. The change statistics was generated as a table and subsequently used to calculate the frequency and magnitude of change. The result of the detection change entirely depends on the accuracies of each individual classification. Image classification and post-classification techniques are, therefore, iterative and require further refinement to produce more reliable and accurate change detection results [8].

Table 3: Error Matrix and Kappa Analysis

Year	Kappa Coefficient	Overall Accuracy
1986	1.0	100%
2006	1.0	100%
2015	0.83	90%
Average	0.94	96.6

The Land Consumption Rate and Absorption Coefficient Formula;

L.C.R = $\frac{A}{P}$ **……………………………………..eqn2**

Where:
A = areal extent of the city in hectares
P = population

L.A.C =$\frac{A2-A1}{P2-P1}$ **……………………………………eqn3**

Where
A_1 and **A_2**are the areal extents (in hectares) for the early and later years, and **P_1** and **P_2**are population figure for the early and later years respectively [40].
L.C.R = A measure of compactness which indicates a progressive spatial expansion of a city.
L.A.C = A measure of change in consumption of new urban land by each unit increase in urban population.

III. Literature Review

Land Use/Cover Change
The terms *Land use* and *Land cover* are not technically synonymous; therefore, the need to draw attention to their unique characteristics to distinguish between them. There are different definitions of land cover and land use among scholars. To this end, a brief explanation of the two terms is provided here from the Encyclopaedia of Earth. Generally speaking, the term land use and land cover change (LULCC) denotes all kinds of human alteration of the Earth's surface. Land cover refers to the physical and biological cover over the surface of land, including water, vegetation, bare soil, and/or artificial structures[6].

Turner [32]believeLand use involves both the manner in which the biophysical attributes of the land are manipulated and the intent underlying that exploitation i.e. the purpose for which the land is used.Lambin[15] differentiate between land cover (i.e. whatever can be observed such as grass, building) and land use (i.e. the actual use of land types such as grassland for livestock grazing, residential area). In fact, the term land use/coverwill be used mainly in this thesis, referring to the land cover and the actual land use.

Interests about land-use/cover change emerged in the research agenda on global environmental change several decades ago with the understanding that land surface processes influence climate. In the mid-1970s, it was acknowledged that land-cover change modifies surface albedo and thus surface-atmosphere energy exchanges, which have an impact on regional climate [22, 4, 27]. In the early 1980s, terrestrial ecosystems as sources and sinks of carbon were emphasized; and this underscored the impact of land-use/cover change on the global climate via the carbon cycle [39,11]. Decreasing the doubt of these terrestrial sources and sinks of carbon remains a serious challenge today. Later, the important contribution of local evapotranspiration to the water cycle - that is precipitation recycling - as a function of land cover highlighted however another considerable impact of land-use/cover change on climate, at a local to regional scale in this case [7].

Much wider range of impacts of land-use/cover change on ecosystem goods and services were further recognized. The primary concerns are impacts on biotic diversity globally [28]], soil degradation [33], and the ability of biological systems to support human needs [38]. Land-use/cover changes also determine, in part, the vulnerability of places and people to climatic, economic, or sociopolitical perturbations [13]. When aggregated globally, land-use/cover changes significantly affect vital aspects of earth system functioning. All impacts are not negative though, as many forms of land-use/cover changes are linked with continuing increases in food and fiber production, in resource use efficiency, and in wealth and well-being.

Being able to understand and forecast the impact of surface processes on climate required long-term historical reconstructions and projections into the future of land- cover changes at regional to global scales [24, 31]. Measuring the contribution of terrestrial ecosystems to global carbon pools and flux required accurate mapping of land cover and measurements of land-cover conversions globally [5, 12, 19]. Fine resolution, spatially explicit data on landscape fragmentation were required to understand the impact of land-use/cover changes on biodiversity [18, 17]. Predicting how land-use changes affect land degradation, the feedback on livelihood strategies from land degradation, and the vulnerability of places and people in the face of land-use/cover changes requires a good knowledge of the dynamic human-environment relationships associated with land-use change [13].

In the last few decades, several researchers have enhanced measurements of land-cover change, the understanding of the causes of land-use change, and predictive models of land-use/cover change, in part under the support of the Land-Use and Land-Cover Change (LUCC) project of the International Geosphere - Biosphere Programme (IGBP) and International Human Dimensions Programme on Global Environmental Change (IHDP) [32, 14]. Various scientists, particularly in the natural sciences, previously assumed that generating local-to global-scale projections of land change several centuries into the past and about 100 years into the future would be easy. In fact, many thought land changes consisted mostly in the conversion of pristine forests to agricultural uses (deforestation) or the destruction of natural vegetation by overgrazing, which leads to desert conditions (desertification). These conversions were assumed to be irreversible and spatially homogeneous and to advance linearly. Basically, the growth of the local population and, to a lesser extent, its increase in consumption was thought to drive the changes in land conditions.

Most contemporary research has principally dispelled these simplifications and replaced them by a representation of much more complex, and sometimes intricate, processes of land-use/cover change. A consensus is progressively being reached on the rate and location of some of the main land changes, but other forms of change, such as desertification, are still unmeasured and controversial. Understanding of the causes of land-use change has moved from simplistic representations of two or three driving forces to a much more intense understanding that involves situation-specific interactions among a large number of factors at different spatial and temporal scales. The richness of explanations has significantly increased, often at the expense of generality of the explanations. At present, only a very few models of land-use change can generate long-term, realistic projections of future land-use/cover changes at regional to global scales. The last decade, however, has witnessed innovative methodological developments in the modeling of land-use change at local to regional scales [17, 37, 23]. All the same, the recent progress in our understanding of the causes of land-use change still has to be wholly integrated in models of the process.

Global Estimates of Land-Use/Land Cover Change

Ever since humans have controlled fire and domesticated plants and animals, they have cleared forests to wring higher value from the land. About half of the ice-free land surface has been converted or substantially modified by human activities over the last 10,000 years. A recent study estimated that undisturbed (or wilderness) areas represent 46 percent of the earth's land surface [20]. Forests covered about 50 percent of the earth's land area 8000 years ago, as against 30 percent today [2]. Agriculture has expanded into forests, savannas, and steppes in all parts of the world to meet the demand for food and fiber. Agricultural expansion has shifted between regions over time; this followed the general development of civilizations, economies, and increasing populations.

Recently, two studies estimated historical changes in permanent cropland at a global scale during the last 300 years by spatializing historical cropland inventory data based on a global land-cover classification derived by remote sensing, which used a hindcasting approach [25], or based on historical population density data [10]. The area of cropland has increased globally from an estimated 300-400 million ha in 1700 to 1500-1800 million ha in 1990, a 4.5- to fivefold increase in three centuries and a 50 percent net increase just in the twentieth century. The area under pasture - for which more uncertainties remain - increased from around 500 million has in 1700 to around 3100 million ha in 1990 [9]. These increases led to the clearing of forests and the transformation of natural grasslands, steppes, and savannas. Forest area decreased from 5000-6200 million ha in 1700 to 4300-5300 million ha in 1990. Steppes, savannas, and grasslands also experienced a rapid decline, from around 3200 million ha in 1700 to 1800-2700 million ha in 1990 [25, 10].

Europe, the Indo-Gangetic Plain, and eastern China experienced first the most rapid cropland expansion during the eighteenth century. Starting in the nineteenth century, the newly developed regions of North America and the former Soviet Union followed suit. China experienced a steady rate of expansion throughout the last three centuries [24]. A very slow cropland expansion occurred in Africa, south and Southeast Asia, Latin America, and Australia until 1850, but since then, these regions have experienced dramatic increases in cropland, especially during the second half of the twentieth century. The greatest cropland expansion in the twentieth century occurred in south and Southeast Asia. The Corn Belt in the United States, the prairie provinces in Canada, the pampas grassland region in Argentina, and, a few decades later, southeast Brazil have also seen rapid expansion of permanent cropland early in the twentieth century [24].

IV. Results

Trend, Nature, Rate and Magnitude of Land use and Land cover Change

Table 4: Land Use / Land Cover Change in Eleme between 1986 and 2006

Land Use Classes	**1986 (Km²)**	**2006 (Km²)**	**Magnitude of Change**	**Annual Frequency of Change**	**Percentage of Change (%)**	**Annual Frequency of Change (%)**
Built-up Area	5.10	18.67	13.56	0.678	72.672	13.296
Farmland	21.20	24.30	3.10	0.155	12.774	0.732
Light Vegetation	82.10	76.79	-5.31	-0.266	-6.920	-0.324
Thick Vegetation	26.01	16.09	-9.92	-0.496	-61.648	-1.907
Water Body	3.69	2.25	-1.44	-0.0721	-64.082	-1.953
Total	**138.10**	**138.09**				

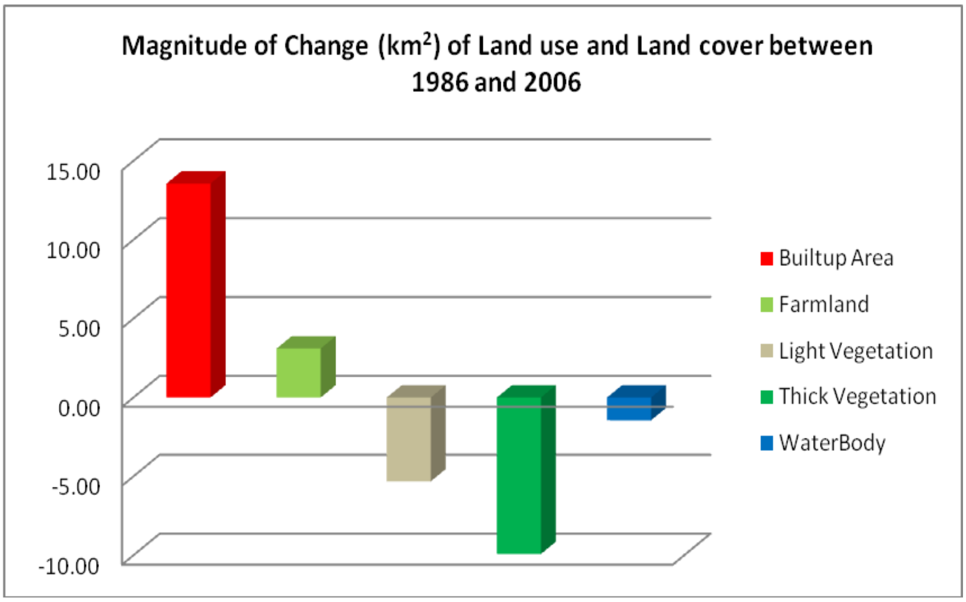


Figure 2: Land use/Land cover Change of Eleme between 1986 and 2006

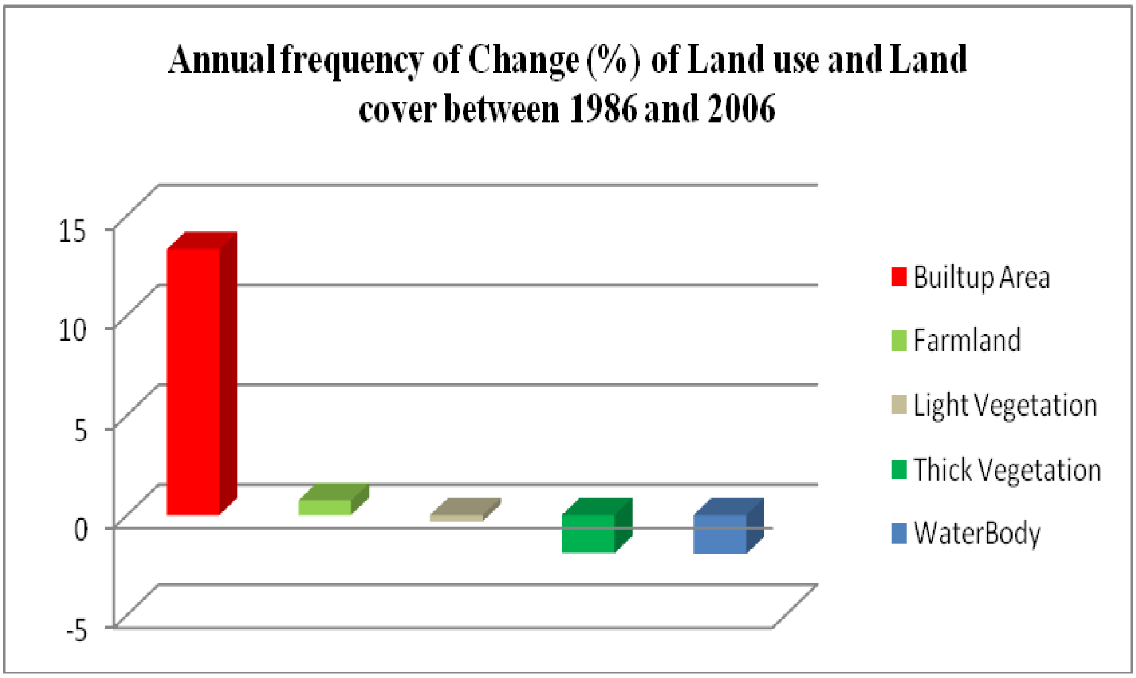
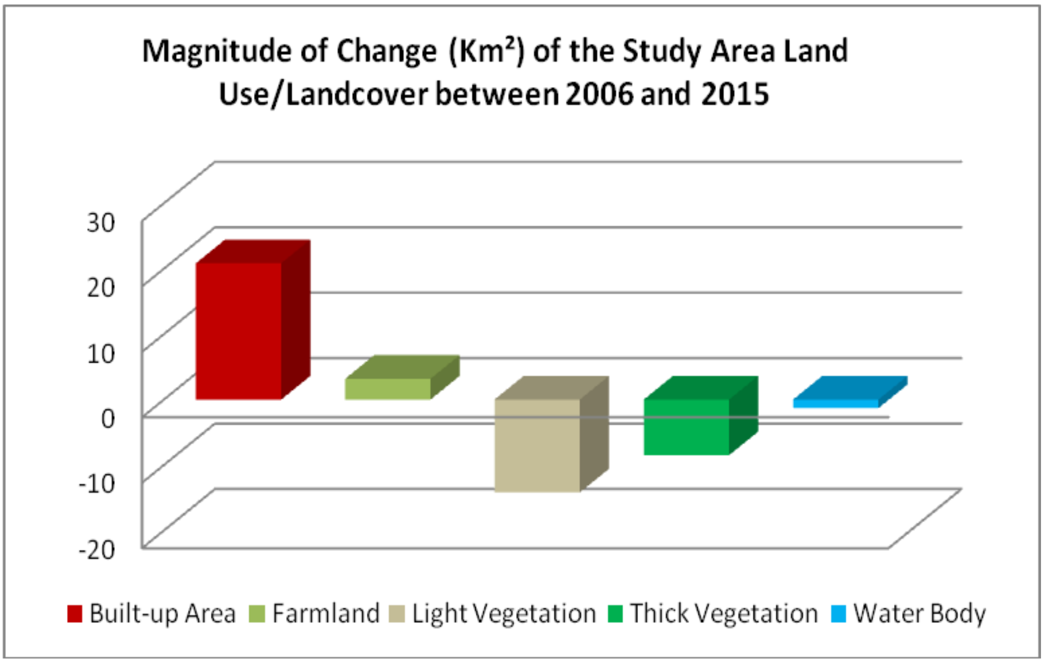


Figure 3: Annual Frequency of Change of Land use/Land cover of Eleme between 1986 and 2006

Table 5: Land Use / Land Cover Change in Eleme between 2006 and 2015

Land Use/Land Cover Classes	2006 (Km^2)	2015 (Km^2)	Magnitude of Change (Km^2)	Annual Frequency of Change (Km^2)	Percentage % of Change	Annual Frequency of Change (%)
Built-up Area	18.67	39.50	20.83	2.315	52.743	12.401
Farmland	24.30	27.48	3.18	0.353	11.556	1.452
Light Vegetation	76.79	62.59	-14.20	-1.577	-22.682	-2.0543
Thick Vegetation	16.09	7.59	-8.50	-0.944	-111.990	-5.870
Water Body	2.25	0.94	-1.31	-0.145	-138.586	-6.454
Total	**138.09**	**138.10**				



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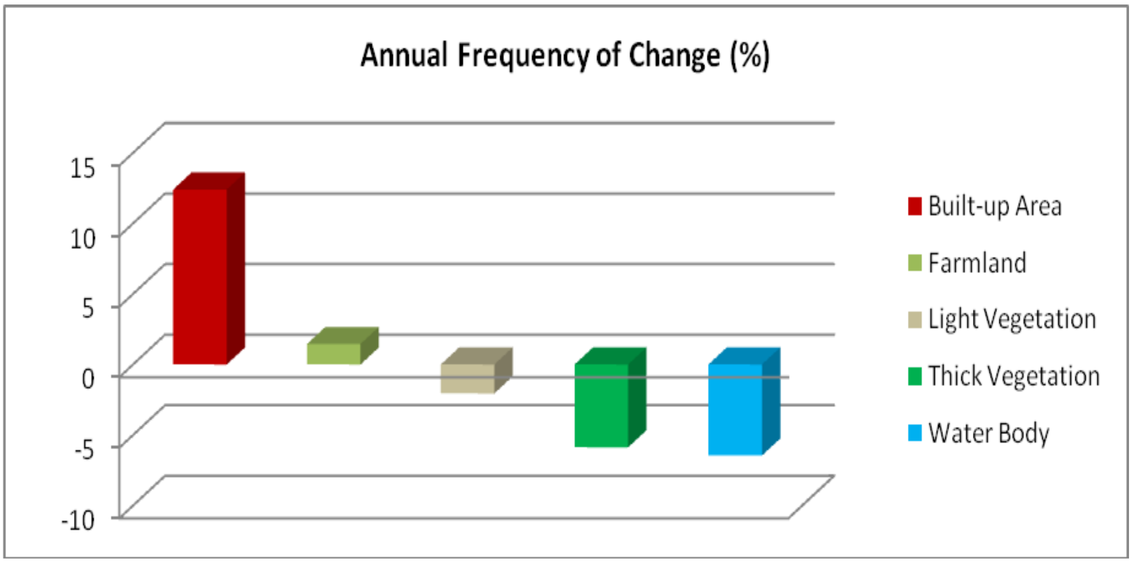

Figure 5: Annual Frequency of Land use/Land Cover Change (%) in Eleme between 2006 and 2015

Table 6: Built-up Area Distribution in Eleme between 1986 and 2015

	1986	2006	2015
Built-up Area (km^2)	5.10	18.67	39.50

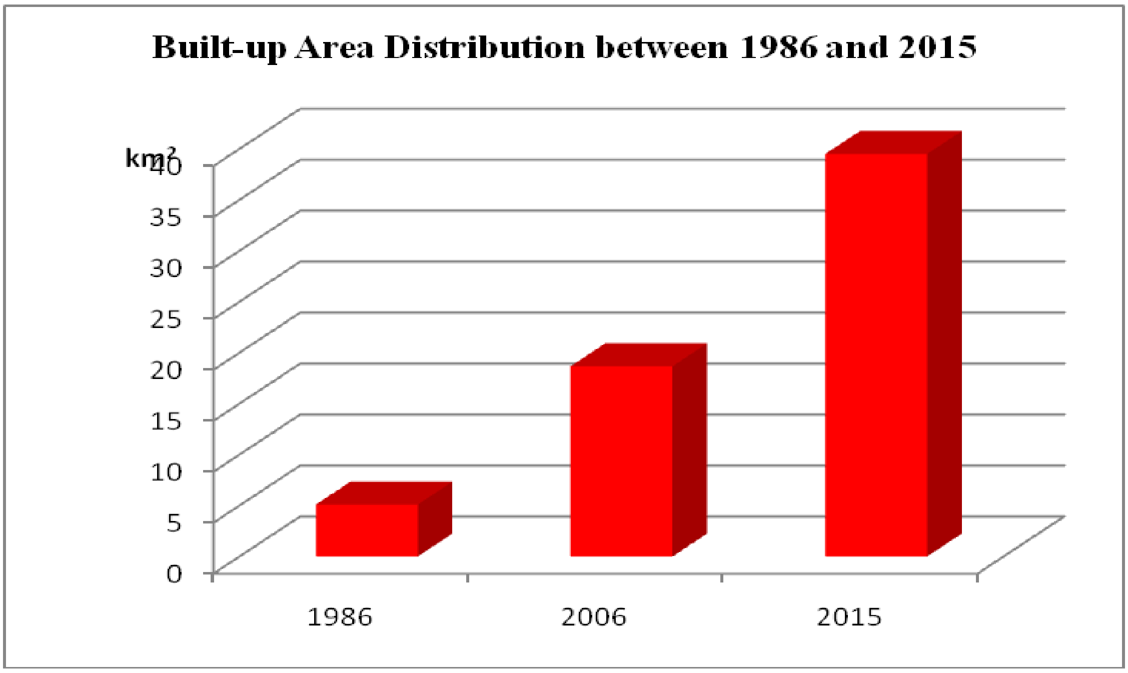

Figure 6: Built-up Area Distribution in Eleme between 1986 and 2015

Table 7: Built-up Area Projection for Eleme between 2006 and 2019

Year	Built-up Area Projected by 2.32 (km^2)
2006	18.67
2007	20.99
2008	23.31
2009	25.63
2010	27.95
2011	30.27

2012	32.59
2013	34.91
2014	37.23
2015	39.55
2016	41.87
2017	44.19
2018	46.51
2019	48.83

Table 8: Built-up Area Projection/Land Consumption Rate in Eleme between 2006 and 2019

Year	Built-up Area Projected by 2.32 (km^2)	Population	Built-up Area Projected by 2.32 (m^2)	Land Consumption Rate (LCR)
2006	18.67	190194	18670000	98.16293
2007	20.99	196661	20990000	106.7319
2008	23.31	203347	23310000	114.6316
2009	25.63	210261	25630000	121.8961
2010	27.95	217410	27950000	128.5589
2011	30.27	224802	30270000	134.6518
2012	32.59	232445	32590000	140.2052
2013	34.91	240348	34910000	145.2477
2014	37.23	248520	37230000	149.8069
2015	39.55	256970	39550000	153.909
2016	41.87	265707	41870000	157.5796
2017	44.19	274741	44190000	160.8424
2018	46.51	284082	46510000	163.7203
2019	48.83	293741	48830000	166.2349

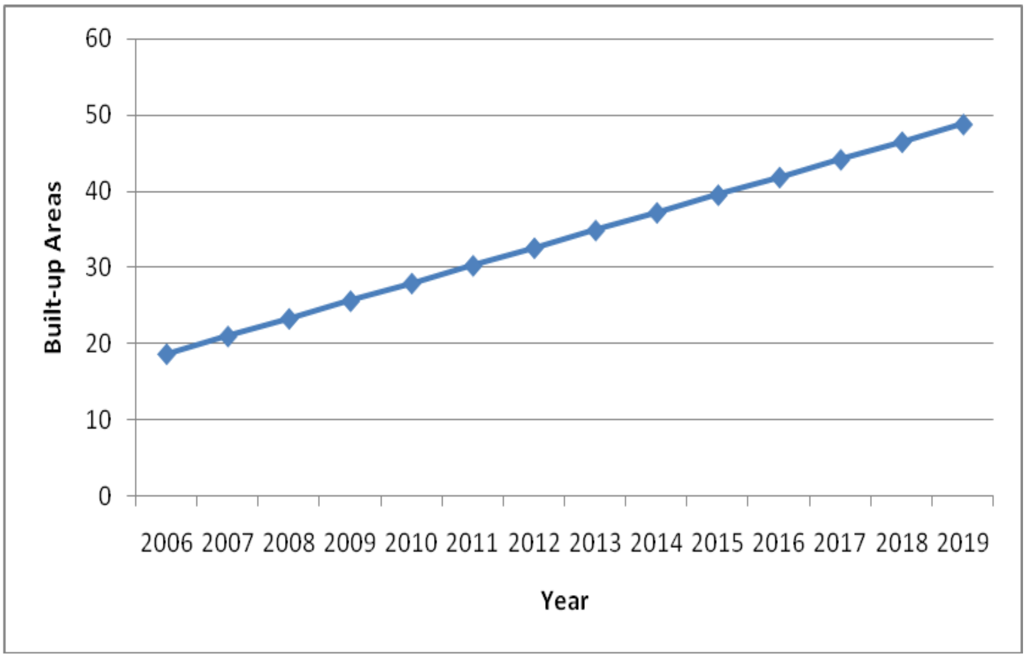

Figure 7: Built up areas and projected rate of Eleme from 2006-2019

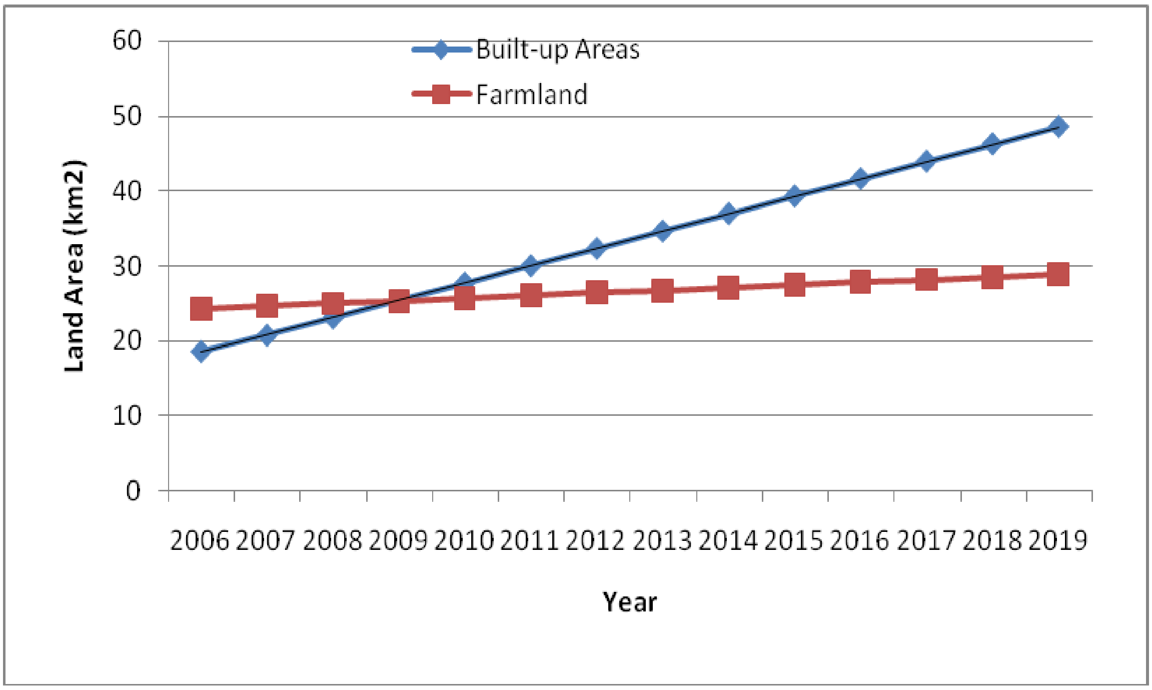

Figure 8: Built-up and Farmland areas and projected rate of Eleme from 2006-2019

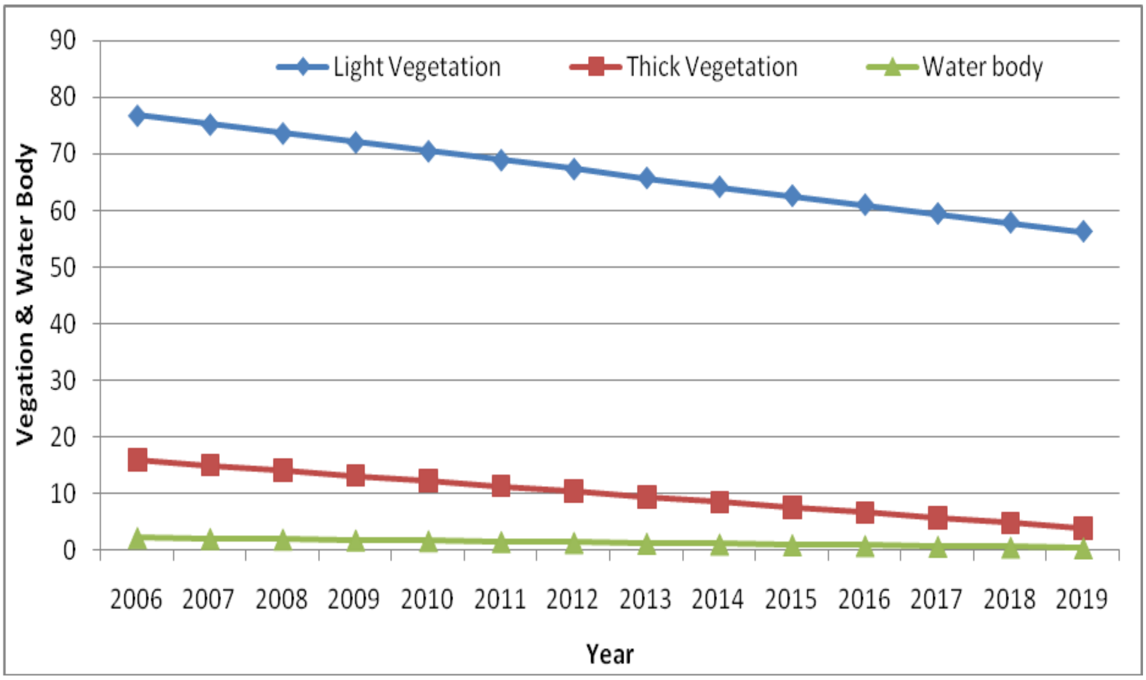

Figure 9: Vegetation Cover and Water body areas and projected rate of Eleme from 2006-2019

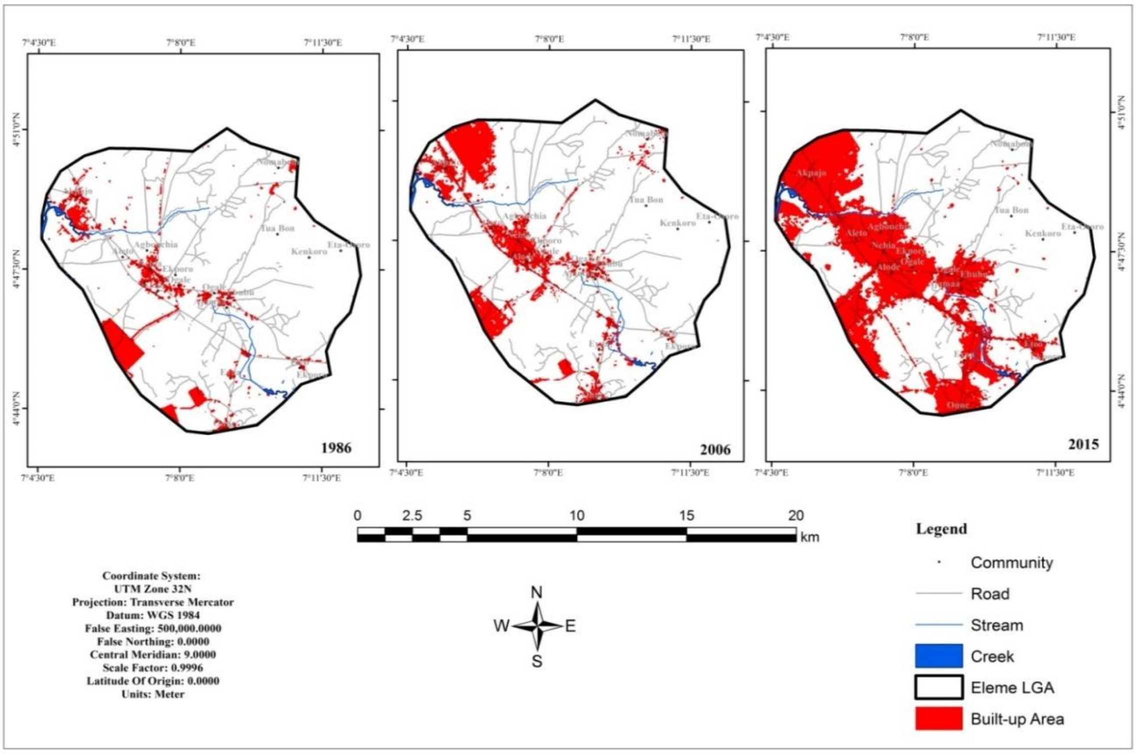

Figure 10: Satellite Imageries of Built-up Area Distribution of Eleme for 1986-2015.

V. Discussion

Table 4 shows the magnitude of change that occurred in built-up area, farmland, light vegetation, thick vegetation, and water body between 1986 and 2006. Accordingly, built-up area increased by 72.7 percent, farmland increased by 12.8 percent while light vegetation decreased by -6.9 percent, thick vegetation decreased by -61.6 percent, and water body decreased by -64.1 percent.

Figure 2 gives a graphic illustration of the magnitude of change in built-up area, farmland, light vegetation, thick vegetation, and water body between 1986 and 2006 as contained in table 4 while figure 3 gives the graphic illustration of the frequency of change for the same period as well.

Table 5 shows the magnitude, percentage, and frequency of change that occurred between 2006 and 2015. Built-up area increased by 52.7 percent, farmland increased by 11.6 percent, light vegetation decreased by -22.7 percent, thick vegetation deceased by -112 percent, and water body decreased by-139 percent. Figure 4 and 5 show the graphic illustrations of the magnitude and annual frequency of change that took place in Eleme between 2006 and 2015.

Table 6 shows built-up area distribution between 1986 and 2015 and figure 6 gives the graphic illustration of this distribution. Table 7 shows the change for built-up area between 2006 and 2019 with an annual increase of 2.32km^2.

Table 8 shows the change in built-up area, population, and land consumption rate. Figure 7 shows the graphic illustration of the change in built-up area between 2006 and 2019 while figure 8 shows built-up area and farmland change for the same period. Figure 9 shows the change in light vegetation, thick vegetation and water body between 2006 and 2019 which were all in serious decline. Figure 10 shows the satellite image of the change that occurred in built-up area between 1986 and 2015 in Eleme.

VI. Conclusion and Recommendations

It is clear from the results andanalyses of available data obtained for this study that the environmental impacts of land use dynamics in Eleme is far-reaching and cannot be overlooked.Built-up areas have continuously increased resulting to a steady decline in light vegetation, thick vegetation, and water body with their adverse effects on livelihoods, climate change, habitat destruction and reduction in biodiversity.

Human activities such as forest conversion and habitat destruction by clearing of light and thick vegetation have been identified as been responsible for the extermination of native animal and plant species for decades now. Also, habitat fragmentation cause suffering to certain animal species by creating barriers to migration and making them more susceptible to environmental disasters such as bad weather, or disease epidemics. The animals can become inbred and vulnerable to genetic flaws.

The shrinking of water body in the area as revealed by this study have equally resulted into pollution of water through natural resources exploration and exploitation like sand and hydrocarbon mining, oil spills, artisanal refining, amongst others.

The land use dynamics show a trend of rapid utilization of the natural resources due to increase in population, industrial development and urbanization.

It is further evident from the results that all key components/classes of Eleme environment like farmland, light vegetation, thick vegetation and water body are fast declining with the likelihood of threatening the carrying capacity of the area over time if allowed to continue unchecked.

We therefore call on all relevant stakeholders and the local authorities to take steps such as aggressive trees planting, use of appropriate farming techniques, proper development control measures, proper wastes management strategies and regimes, an amendment to the Land Use Act of 1978 to check the excessive acquisitions of lands by governments at all levels, and other measures that would safeguard the environment and reduce the rate of natural resources depletion in Eleme.

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