

**UNIVERSITY OF GHANA
DEPARTMENT OF GEOGRAPHY AND RESOURCE DEVELOPMENT**

**ASSESSING LAND USE AND LAND COVER CHANGE IN THE KETA
MUNICIPALITY OF GHANA USING REMOTE SENSING**

BY

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DECLARATION

I hereby declare that this Mphil thesis is my own work. It contains no materials previously published by another person or materials which has been accepted for the award of any other degree elsewhere except where due acknowledgment has been made in the text.

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DEDICATION

To the Almighty God from whom comes all that is good. To my ever-caring mum, Madam Catherine Sosoo, my ever-loving brother Mr. Gabriel Peters and my ever-favourite Rev. Fr. Derek Mawuli for being there for me throughout this journey.

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ABSTRACT

Coastal areas around the world are increasingly facing devastating disasters due to land use and land cover changes. Same can be said of Keta Municipality which experiences series of challenges such as unplanned urbanisation, intensive agriculture, flooding and coastal erosions. To design better solutions to these recurring problems, there is the need to understand the landscape and its interaction with its inhabitants. To achieve this, this study employed remote sensing techniques by acquiring historically sensed data of 1991, 2005 and 2018. The focus of the study was to determine the various land use and land cover types that exist in the study area and also examine the changes that have occurred over the years. The study established that the Keta Lagoon remained the most dominant land cover from 1991 to 2018 occupying 267.5km² and 282.01km² respectively. Wetlands which are known to be flood protection agents have however reduced from 182.33 km² to 135.11 km² from 1991 to 2018. Agricultural activities have been on the rise in the Municipality and is evident in the surface area farmlands covered by the year 2018. This rise may be understood to keep up with the population growth in the municipality. However, the conversion of wetland areas into agricultural lands has exposed human settlements to issues such as floods and coastal erosions. In view of these revelations, there is the need for intensification of education on the benefits of wetlands in the protection of lives and properties in the area. In the short term, farming activities need to be regularised by the local government so that wetlands will be allowed to regenerate.

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LIST OF ACRONYMS

ENVI.....	Environment for visualizing images
FAO.....	Food and Agriculture Organisation
FIG.....	Figure
GIS	Geographical Information Systems
GSS.....	Ghana Statistical Service
LULC	Land Use and Land Cover
MoFA.....	Ministry of Food and Agriculture
NADMO	National Disaster Management Organisation
ROI.....	Region of Interest
RS.....	Remote Sensing
UNESCO.....	United Nations Educational, Scientific and Cultural Organisation

CHAPTER ONE

GENERAL INTRODUCTION

1.1 Background to the Study

Humankind has dramatically transformed much of the Earth's surface and its natural ecosystems. Many natural ecosystems are being progressively razed, bulldozed, and felled by axes or chainsaws until only small scraps of their original extent survive (Laurence, 2010). The negative effect of these transformations is land use and land cover change. Gebrehiwet, (2004) explained that land cover has undergone continuous change for millennia, a change that resulted from the use of fire for game hunting and clearance of patches of land for agriculture and livestock production since the advent of plant and animal domestication. This is because the insatiable needs of humans cannot be fulfilled without modification and/or conversion of land cover. This conversion of the natural habitat to satisfy human's wants leads to land use which according to Sherbinin (2002) is the term used to describe human uses of land, or immediate actions modifying or converting land cover. On the other hand, land cover refers to the physical and biological cover over the surface of the earth, including water, vegetation, bare soil, and/or artificial structures (Ellis, 2010).

Wetlands have been identified by various scientists as a protective agent against storm surge (RAMSAR, 2014; Gulbin et al, 2017; Li et al, 2017). Sadly, since the 19th century, wetlands have been diminishing globally (Li et al, 2017; Gulbin et al, 2017, Adade et al, 2017; Asante et al, 2017). In a changing climate, the role of wetlands in flood control becomes even more important (Gulbin et al, 2017). Blankspoor et al, (2017) posited that as storm surges increase, they will create more damaging flood conditions in coastal zones and adjoining low-lying areas. If mangroves can migrate inland with a possible retreat of the coastline, then they will still provide coastal protection

even in a changing climate (Al-Tahir and Ali, 2011). However, if mangroves cannot migrate inland or if migration of mangroves is at a risk, then they may not continue to provide coastal protection services in a changing climate (Anthony, 2005).

The idea that mangroves may protect coastal communities from coastal hazards (coastal erosion, tidal bores, wind and salt spray, cyclones, etc.) is well known in tropical coastal ecology and increasingly by coastal managers (UNEP-WCMC 2006; Blankespoor, 2017). While coastal wetlands are facing losses, many countries have started taking measures to rebuild marshes with dredged sediments, or divert the river channels to elevate ground surface (Li et al, 2017). These restorations efforts are corroborated by Blankespoor et al, (2017) which reported that awareness of the role of mangroves in coastal protection has led to large-scale programs to rehabilitate and replant mangroves in countries like Vietnam and the Philippines as well as small programs in many other countries. Kusimi (2015) earlier posited that protected areas have expanded globally in order to conserve biological and cultural resources as it is recognized that such areas are effective in protecting some kinds of biodiversity. He further acknowledged that despite the high level of protection given to national parks and other protected areas, many are not functioning well as originally envisioned owing to ecological pressures such as fires, floods, climate regimes, and expansion of human activities on lands surrounding protected areas.

Ghana has ratified many conventions one of which is the Ramsar Convention in 1988 which led to the designation of the Keta Lagoon Complex and Songor Ramsar Sites and subsequently to the enactment of the Wetlands Management Regulations in 1999 (Padi, 2007). The prime focus of these legislative frameworks was to protect, conserve and sustainably utilize wetlands of international importance. One major obligation under the Ramsar Sites Regulations 1999 was to ensure the implementation of the principle of “wise use” of these wetlands and their resources,

without compromising the ecological integrity of the wetlands (Braumoh and Vlek, 2009). Within the context of coastal environment, the government and other stakeholders have shown commitment towards the protection and management of the natural resources as indicated by the drafting of various strategy documents such as the Coastal Zone Management Indicative Plan, Integrated Coastal Zone Plan, National Wetlands Conservation Strategy and Action Plan, including many other restoration and conservation projects (Asante et al, 2017). This notwithstanding, the wetland ecosystem is gradually decreasing (Adade et al, 2017).

The changes of the natural ecosystems can be informed by the level of human activities in the quest to attain individual wants. Kusimi, (2015) citing Jaiswal et al, (2011) stated that the restless pursuit of progress by mankind, comfort and security has resulted in increased stress on the environment which led to land use/land cover (LULC) changes over a period of time. Today, there is an increasing reliance on remote sensing in monitoring land use and land cover change (Kusimi, 2008; Yiran, 2012; Kusimi, 2015; Adade, 2017; Gulbin et al, 2017). The integration of Remote Sensing for land use and land cover change is necessary for monitoring and managing urban development and natural resources because it provides changes that have occurred, the nature of the change, the extent of the change and the spatial pattern of the change. Using the Keta Municipality as a case study, this study intends to employ remote sensing to assess the LULC changes that have occurred and investigate the likely effects of these changes on the ecosystem of the Municipality.

1.2 Problem Statement

When humanity's ecological demand exceeds its supply it assumes a phenomenon called ecological overshoot (Wackrangal et al, 2002). This ecological overshoot is what leads to LULC changes. Probably one can say, one of the most important changes on global environmental change is LULC change since it occurs at spatial and temporal bases relevant to our existence (CCSP, 2003). Issues of greenhouse effect, food shortage, deforestation, are often related to LULC changes. It is germane therefore to analyse LULC to develop a sustainable land use plan and update land use information. Spurning from the late 1960's, the quick growth of the concept of vegetative mapping has thrown more spotlight on land use and land cover changes globally. Attaining accurate assessment on the extent and health of forests, agricultural resources and aquaculture farms which have become a prominent priority (Muttitanon and Tripathi, 2005).

A study by the Centre for the African Wetlands in 2014 on LULC cover on the Songor Ramsar Site revealed that between 1990 and 2007, there had been a significant reduction and degradation of healthy vegetation cover from 3087 hectares to 1308 hectares. Field analysis and observations of current aerial photographs of the Songor Ramsar site depict that the wetland landscape indicated spatially fragmented patches interspersed and surrounded with a matrix of agricultural fields, saltpans, settlements and drainage ditches (Adade et al, 2017). Information from land use /land cover allows to detect where changes happen, what type of change as well as how the land quality status is changing (Bajocco et al, 2012). On the other hand the data aids decision makers to build short and medium term plans for the sustainable use and conservation of natural resources (Jansen and Di Gregorio, 2004).

Change detection of Land use on spatial basis would be a prominent requirement for building effective planning strategies and land management in many coastal areas (Muttitanon and Tripathi, 2005).

In Keta Municipality, existing studies proved that wetlands which are mostly controlled by the local communities, have become more vulnerable as a result of increasing human use such as reclamation for residential and industrial purposes (Ryan & Ntiamo-Baidu, 2000; Adade, 2017). Another research reveals that the land of the Keta Municipality is predominantly agricultural and some aspects of it are undergoing deforestation and abandonment hence land use change analysis would give information on the intensity of these conversions (Gyawali et al, 2014).

One of the important roles of wetlands is reduction of flood risks but Gulbin et al, (2017) recognized that globally, the area of wetlands is shrinking with multiple impacts on water quality and ecosystems.

The Keta Municipality has not been an exception from such changes. Some of the changes that have been observed include the conversion of the wetlands into farmlands, and settlements. This is affecting the distribution of living organisms since they are losing their natural habitat. Also, harvesting of the mangrove for domestic activities is affecting the biodiversity through the fragmentation of natural habitat. (Boateng, 2010).

The Keta Municipality is experiencing interacting problems due to a combination of poor land use planning. Dealing with issues of land use change in the Keta Municipality is a complicated issue because it finds itself at the crossroads of several policies (Boateng, 2009).

In the Keta Municipality, the drivers of LULC change are commercial agriculture, fragmentation of habitats, unplanned human settlement, saltwater intrusion, siltation and destruction of

mangroves and coastal erosion (Yaa- Baidu et al, 2015). Sand mining which occurs in the Keta Municipality plays a significant role in land use and land cover change (Mensah, 1997). Forms of mining along the beach reduces the beach's volume hence an effect on the LULC. According to Biney et al. (2005), the land use and land cover changes that occurs in the Keta area has reduced many vegetative species such as mangrove, cacti, coconut trees and raffia palm. The destruction of the Keta vegetation including plants such as mangroves has negative consequences (Braumoh and Vlek, 2005). Furthermore, improper disposal of domestic wastes and the use of chemical fertilizers and organic manures in farms, bush burning, charcoal production (Akrasi, 2005; Yidana, 2010) are all forms of anthropogenic activities affecting the use of land. The real threat to wetlands in coastal areas today is agriculture (Laurence, 2010; Gulbin et al, 2017). Even though the Keta area is undergoing land use and land cover changes especially in areas of farming and infrastructure for the good of the communities its negative effects are on the ascendancy rendering most areas more venerable with time.

This research therefore, intends to investigate land use and land cover changes in the Keta Municipality and determine how these changes can help city planners and wetlands managers in developing well-tailored policies towards sustainable management of wetlands and long lasting solutions to recurring land related issues. It is therefore necessary to identify and measure these changes as to understand linkage between land cover changes and how they can yield essential information which can be used by coastal managers in order to understand land use and land cover change processes for decision making. Hence there is the need for local spatial information on prominent land use transfers and changes in the land cover of the municipality.

1.3 Research Question

1. What are the areal extents of the land use and land cover types in the Keta Municipality as at 1991, 2005 and 2018?
2. What are the changes that have occurred in the study area from 1991 to 2018?
3. What are the driving forces behind the land use and land cover change in the Keta Municipality?

1.4 Objectives of the Study

The main objective of the study is to investigate the land use and land cover changes that have occurred in the Keta Municipality landscape from 1991 to 2018. Specifically, the research seeks to:

1. Identify the land use and land cover types in the Keta Municipality from 1991 to 2018.
2. Estimate the areal extent of land use/land cover for the respective years of 1991, 2005 and 2018.
3. Quantify land use/land cover changes from 1991-2005 and from 1991-2018.

1.5 Proposition

Over time, land cover is likely to undergo changes as a result of natural occurrences and human interaction with the environment.

1.6 Significance of Study

It is estimated that over 70% of the world's sandy beaches are experiencing LULC changes and this presents a serious hazard to many regions. These problems are as a result of anthropogenic activities or natural events. The conversion of wetlands into farmlands and settlement, sand winning, removal of river materials, destruction of sand dunes, subsidence by the artificial extraction of water, flood risks, intensive farming, infrastructural development, port development, rapid urbanization, land subsidence, and increased coastal populations are some of the anthropogenic issues while natural issues include climate change which affect coastal farming practices, influential rainfall patterns, increase sea level elevation and impact on water resources (Lawson et al, 2012). These issues are critical for the understanding of coastal systems and their effective management (Al- Tahir and Asim, 2004). Issues associated with coastal environmental changes, modifications in ecosystem structures and the loss of biodiversity have aroused worldwide public interest (Cohen and Manion, 2015).

The study on land use and land cover will indicate either a decline or rise of vegetation like mangroves since the ecological function of mangroves is enormous and prominent in cutting down erosion and flooding in the area. Anthropogenic activities within the Keta Municipality have created adverse environmental and social consequences such as mangroves degradation, salinity, pollution, unemployment, poor living standards etc. It is therefore necessary to measure and identify changes in the land use to understand linkage between land cover change and how they can affect the landscape (Syvitski et al, 2009). This will also yield essential information which can be used by coastal managers in order to understand land use and land cover change processes for decision making (Congalton and Greek, 2009). Hence, there is the need for local spatial

information on prominent land use transfers and changes in the land cover of the Municipality (Sader and Hayes, 2011).

1.7 Limitations of study

The research was not carried out without certain constraints. Among the constraints encountered were data collection and the difficulty to obtain cloud-free Landsat satellite data of the Keta Municipality. Notwithstanding the constraints and other challenges, it can be emphasized that the research was successful.

1.8 Organisation of study

This study is divided into five (5) segments. Chapter one is about the general introduction, followed by the problem statement, the research questions and the objectives of the study. It also captures the significance of the study, limitations in the study and the outline of the rest of the chapters.

Chapter two deals with the existing literature on land use and land cover changes and the use of remote sensing in land use and land cover studies.

Chapter three highlights the study area as well as the research methods and materials used. The chapter first describes the study area both with respect to its physical and anthropogenic features. The second section thoroughly explained the research methodology of the study.

Chapter four talks about the findings, data analysis and discussions. It also presents some results in pictorial form, tables and charts in the main text.

Chapter five presents summary of key findings. It also contains the conclusions and recommendations to the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter entails the literature review of the research. The literature review reveals the various approaches and methods in which various researchers dealt with similar topics and the deductions and conclusions that were made. The review is arranged along these themes; land use and land cover, the use of remote sensing in LULC change studies, accuracy assessment and change detection.

2.2 Land Use and Land Cover

The terms land cover and land use (LULC) are often used interchangeably but their actual meanings are not synonymous (Firdaus, 2014). Land use refers to the function of land to humans which usually emphasizes the importance of land in an economic activity (FAO, 2005). It includes all the arrangements, activities and inputs undertaken in a certain land cover type in order to reap social, cultural and economic benefits whereas land cover is the physical appearance of land surface which provide visible prove to land use (Darlrymple et al, 1992). In principle, land cover is more obvious on the field than land use that is usually inferred from the cover. These two words are closely linked such that in mapping they are treated together to avoid ambiguity (Ibe and Queleennac, 2011). Sometimes there is difficulty in separating the two terms due to the complex feedback loop that exist between them, making it difficult to distinguish effect from cause (Holt et al, 2009). LULC share a common source of change in the form of human activities that directly

alter the physical environment (Crowell et al, 2010). Over the years, humans have been trying to mine higher value from the land by converting or modifying the natural cover types through diverse uses (Hendry and Digafeldtk, 2017).

LULC has been changing since people first began to manage their environment (Harris and Ventura, 2006). LULC is a complex process and deserves a careful study to understand. Land cover change analysis is used to assess changes that happen over time by identifying different classes and detecting changes (Forkour et al, 2014). This helps in understanding the behaviour of systems with time and how it is being affected by both natural and anthropogenic activities (Giri et al, 2007). Studies on LULC help to locate areas facing deterioration in land resources (Gyawali et al, 2014) and areas that are protected. Land cover changes have major effects on both biotic and abiotic segments in the earth's ecosystems (Koranteng et al, 2017). Human habitation on earth and its associated activities have yielded many changes in the landscape, which have resulted in adverse effects on the environment (Koranteng et al, 2017).

Changes in land cover are eminent, progressively quick and have major impacts and repercussions on global, regional and even local scales. The land use change concerned agricultural changes and development of new nature areas from agricultural land. Individually, Land use changes had the biggest effect on vegetation distribution and composition (Van der Knaap et al, 2018). Biodiversity affects land use as well and according to Cruz (2013), factors relating to biodiversity depletion are non-segregation. Brown et al, (2013) estimated that the world's forests were converted to other land use at a rate of 0.38% (that is deforested) annually in the 1990s. This issue is swifter and more diverse in developing tropical countries (Asubonteng, 2007). According to Sierra-Correa and Kintz, (2015), the driving forces of LULC change vary and their dynamic interactions result in diverse chains and trajectories of change depending on the scientific, environmental, social,

political and historical context from which they arise (Denutsui et al, 2012). Several researchers have demonstrated that landscape conversion can easily be monitored and documented (Forkour et al, 2015). Hence, over emphasis on conversion diverts attention from land cover modification, which also has important effects on the landscape (Meyer and Turner, 2002). The complexity of land cover change is illustrated by the functional differences within types of land cover, structural variance between types of land cover change with regards to spatial arrangement and temporal patterns of change (Ellison and Stoddart, 2018). The high spatial variability in land cover, biophysical and socio-economic drivers of land use change worldwide results in the variability in the causes and processes of land use change (Dean, 2009). The dynamic nature of land use and land cover change makes it impossible to have an ideal solution for all problems associated with land use and land cover change in different areas and at different spatial extents (Asubonteng, 2007). It is therefore important to capture the understanding of land use and land cover change dynamics and their socio-economic drivers at local hotspots where they are most prominent (Giri et al, 2007).

Land use changes potentially have effects on floods and erosion as humans have modified the landscapes (Viglione et al, 2016). When agricultural practises are intensified it consequently affects buffer processes, soil horizons, hydrological significance as well as lateral flows and infiltration processes. These changes then go a long way to induce the phenomenon of erosion and flooding (Komar, 2017).

In the Madarsu Basin in the Golestran province of Iran, research revealed the intensity of floods increasing from 1960 to 2002 accompanied by decreases in natural lands of forests, rangelands and barelands from 1960-2002 (Shalaby and Tateishi, 2007). In August 2001, flood in this Basin caused about 30 million dollars of economic losses and 300 human casualties. In the Kasilian Basin

also in Iran, the reduction of the forest lands increased the surface runoff (Sadeghi, 2005). The same results were indicated on the hydrographs of Neka River, during the deforestation activities of 1967-2000 period (Pouraghnyaii, 2011) and after the forest cuttings in the Gilan province of Iran. Anthropogenic interventions such as expansion of surfaces (which are impermeable through the urbanisation processes) are the factors which have resulted in the flooding (Panahi and Alijani, 2010).

A study by Apollonio et al, 2016, identified that in the Cervaro River Basin in Southern Italy, the flooding areas showed non-negligible land use changes for 30 years under study. Other researches done in the basin, but this time covering a larger dimension can be seen to have negligible correlation of land use changes (Estoque and Murayama, 2011). This showed good correlation between flooding areas and land use changes, particularly an increase in flooding areas related to a rise in the water proofing due to urbanisation growth. Clearly, flooding has increased since urbanisation has taken over agricultural areas in the area (Apollonio et al, 2016). Kathresan and Rajendran (2013) mentioned unprecedented increase in population: the growing influence in Europe, North America and part of Asia and Latin America. The worldwide changes in lifestyles, which are partly explained by rising per capita income and the growing influence of geopolitical, economic and military structures and strategies are important drivers (Estoque and Murayama, 2012). The negative addition of the rapid human population growth to the large pressure on land resources has been noted by most literature on land use and land cover change (Kirschbaum and Hetlinger, 2015) On the contrary, Turner et al, 2003 found that land use may intensify without associated change in land cover if development occurs under natural conditions. For example, under the forest canopy. Essentially the driving forces are usually remote in space and time from

observed changes and often involve macro-economic transformations, technological effects, socio political factors and policy changes, which are difficult to expect (Irvine, 2009).

Land use analysis was performed in Likangala (Malawi) where the study revealed impact on the catchment area where there was soil erosion, siltation, river flow, water quality and fish harvesting between the years 1982 and 1995 (Jamu et al, 2003). Another study done by Pullanikkatil et al, 2018 indicated a decline in woodlands and wetlands since 1984. The study revealed catchment degradation by activities such as water disposal, deforestation, illegal sand mining. There is increasing trend in cultivation at urban areas alongside farming on marginal lands such as hill slopes and wetlands (Cui et al, 2015). It is believed, urbanisation and demand for agricultural lands have contributed to land use land cover change (Jensen, 2005).

Ghana, like many developing countries whose economy depends largely on agricultural production and the intensification of timber export, minerals and other natural resources, is not an exception to land use and land cover change problems (Bruinsma, 2018). The forest and other coastal resources (example wetland, lagoon, estuary and others) play an important role in the economy of Ghana. Ghana's landscape has been categorized into land use classes such as small and large-scale farming, forestry, wood fuel, trees and coastal zones of exotic and indigenous species and game park reserves in order to provide goods and services (Songsore, 2003). However, deforestation stands out as one of the most prominent change factors within the Ghanaian landscape (Asubonteng, 2007). Office accommodation, residential and lateral expansion is the status quo in most communities in Ghana often leading to the neglect of other land uses as infrastructural development sprawls (Attua and Fisher, 2011).

In the western region of Ghana, satellite image analysis done between 1990 and 2010 showed a projection that from the years 2020 to 2040 there would be a steady increase in built up areas.

Protecting natural resources is important in the equilibrium of every ecosystem (Kufogbe, 1997). Problems such as soil erosion and increased run-off can occur due to rampant changes and the destruction of natural resources (Jonah, 2015).

2.3 Drivers of Land use and Land cover change

Drivers of land use and land cover include climate change, population growth and urbanisation, economic, socio political, cultural and religious, invasion of pest and diseases, scientific and technological but these drivers do not act in isolation, but interact to produce outcomes that most are detrimental to human existence (Basommi et al, 2015).

Drivers impact on the land use and land cover changes directly and indirectly. Land conversion is a direct driver of Land Use and Land cover change. Humans change land use to alter the mix of ecosystem services provided by that land. Sometimes the land conversion effort is intentional, such as ploughing grasslands to grow crops, cutting down forest to make way for farming. In other cases, land conversion is a consequence of other activities. For example, sand winning is a consequence of urban development/ road construction (Bajocco, 2012). According to Kusimi, 2008, vegetation cover and soils have been removed by the actions of artisanal miners leaving huge excavations on the land in Wassa West district of Ghana. This findings was further confirmed by the community leaders.

Biological invasions are the global phenomenon affecting ecosystems in most biomes (Mack et al. 2000). Ecosystem changes brought about by invasions can have both short-term or ecological and long-term or evolutionary consequences. In some ecosystems, invasions by alien organisms and

diseases result in the extinction of native species or a huge loss in ecosystem services. For example, the invasion of cocoa farms by black pod disease leads to the loss of farms (Stow et al, 2013).

In the case of demographic drivers and urbanisation which is an indirect driver, population growth depends on the demographic factors such as fertility, mortality and migration. As population grows, there will be increasing demand for food, fibre and shelter (e.g. Kuusaana and Eledi, 2015; Kleeman et al., 2017). The demands will alter land use. For example, more land will be required for housing. Increase demand for food means increase food production through bringing more land under cultivation or intensification. This has a correlation with land conversion. Population growth lead to urbanisation, infill and sprawl (in terms of physical development) (Cobbinah et al., 2017).

Studies by Kusimi, 2008 on the Wassa West district revealed, apart from the supply of food, an increase in urbanisation has led to housing demands on surrounding lands. This has also resulting in forest degradation in the area.

Additionally, economic drivers which touches on consumption, production and globalisation is also an indirect driver. Economic activity is a consequence of humans striving to improve their well-being (Sierra-Correa et al, 2015). The outputs of this activity are determined by natural capital, human capital, manufactured capital and social capital. Human wellbeing is clearly affected by economic growth and its distribution. Income received by individuals and families determines their level and nature of consumption. Total world food consumption is expected to increase by over 50% by 2030 (Bruinsma, 2003). As per capita income grows, the nature of consumption changes, shifting from basic needs and services that improve the quality of life. This transformation of consumption patterns is a consequence of two related facets of human behaviour: The limit to the quality of food one human can consume and the desire for diversity. The first result

of the Engel's law, which states that, as income grows, the share of additional income spent on food declines (Hamilton et al, 2001). The second is a shift in the primary source of calories from starchy staples, eg., rice, wheat, root crops, to diverse diets that include more fat, meat and fish as well as fruits and vegetables as the ability to afford these food groups rises; this phenomenon is known as Bennett's law (Timmer, 1997)

Globalisation increases the worldwide interconnectedness of places and people through markets, information and capital flows, human migrations and social and political institutions (Roy and Roy, 2012). Over the last 300 years, there has been an increasing separation between the location of production and consumption in the world's economy. Economic globalisation also increases the influence of large agribusiness enterprises and international financial flows on local land use decisions, in some cases weakening national policies intended to promote a public good (Lui et al, 2017).

Socio-political drivers may be some of the most fundamental elements of how humans influence the environment (Mendoza-Ponce et al, 2018). One important element of socio-political drivers, i.e. human conflicts acts both as a direct and an indirect driver of change in ecosystem services and human well-being when nature becomes the recipient of "collateral damage". War-driven environment degradation can initiate social degradation and protracted cycles of social and environmental decline by creating poverty, over exploitation of marginal resources, underdevelopment and in extreme cases, famine and social destruction (Berhe, 2000).

To understand culture as a driver of ecosystem change, it may be most useful to focus on the values, beliefs and norms that a group of people share and that have the most influence on decision making about the environment. Kusimi, 2008 alluded to the fact that minimum attention has been

given to land use and land cover changes when it comes to the political structure, political economy and cultural values of the people but these forces are critical in shaping the land use changes of an area. In this sense, culture conditions the individual's perceptions of the world, influences what he or she considers important and suggests courses of action that are appropriate and inappropriate (Kumi-Boateng et al, 2012). In land use, culture could relate to crops grown, types and forms of buildings, where land conversion is allowed, etc. These helps change the land use and land cover of a particular society (Koranteng et al, 2017).

The development and diffusion of scientific knowledge and technologies that exploit knowledge have profound implications for land use and land cover change. The application of technology has been in the areas of crop breeding, cross-breeding of livestock, fertiliser production, mechanization, irrigation etc. and in recent times, agro processing. Others include modern construction, conservation telecommunication, modern health care, etc. These have implications for land use and land cover changes (Coulter et al, 2013).

Environmentally, there is an indirect impact on land use and land cover changes. Land use and land management practices have a major impact on natural resources including water, soil, air, nutrients, plants and animals. Land conversion leads to deforestation (Russell and Ward, 2016). Runoff from agriculture is a leading source of water pollution both in inland and coastal waters. Drainage wetlands for crop production and irrigation water diversions has had a negative impact on many wildlife species. Irrigated agriculture has changed the water cycle and caused groundwater levels to decline in many parts of the world (Estoque and Murayana, 2012). Intensive farming and deforestation may cause soil erosion, salinization, desertification, and other soil degradations. Deforestation adds to the greenhouse effect, destroys habitats that support biodiversity, affects the hydrological cycle and increases soil erosion, runoff, flooding and

landslides (Boateng, 2013). Urban development causes air pollution, water pollution and urban runoff and flooding. Habitat destruction, fragmentation and alteration associated with urban development are a leading cause of biodiversity decline and species extinctions. Urban development and intensive agriculture in coastal areas and further inland is a major threat to the health, productivity and biodiversity of the marine environment throughout the year.

Lastly, there are socioeconomic drivers, Conversions of farmland and forests to urban development which reduces the amount of land available for food and timber production. Soil erosion, salinization, desertification, and other soil degradations associated with agricultural production and deforestation reduce the amount of open space and environmental amenities for local residents. Urban development reduces the *critical mass* of farmland necessary for the economic survival of local agricultural economics. Urban development patterns not only affect the lives of individuals, but also the ways in which society is organised. Urban development has encroached upon some rural communities to such an extent that the community's identity has been lost. Suburbanization intensifies income segregation and economic disparities among communities (Forkour et al, 2015). Excessive land cover control, however, may hinder the function of market forces. Land use regulations that aim at curbing land development will raise housing prices, making housing less affordable to middle – and low income households. Land use regulation must strike a balance between private property rights and the public interest (Bhattachan et al, 2018).

2.4 Remote Sensing for Land Use Land Cover

The use of Remote Sensing (RS) provides an alternative for growth areas to be effectively mapped and monitored (Ozesmi and Bauer, 2012). Such technologies offer a significant access to spatial problem solving and have played a very significant role in management and urban growth. With these technologies, growth rates and patterns can be determined, quantified and planned for alternative future scenarios (Otoo et al, 2006). Kusimi (2015) reported that the conventional methods of detecting LULC changes are costly, slow, low in accuracy and present a picture of only a small area whereas remote sensing, because of its capability of synoptic viewing, digital format and repetitive and large coverage, provides useful and cheaper information on temporal LULC dynamics from multi-date imagery (Coppin et al, 2017; Roberts et al, 2003; Yiran et al, 2012; Kusimi, 2015). Remote sensing also provides broad, precise, impartial, and easily available information for quantifying the location, extent, and variability of change; the causes and processes of change; and the responses to and consequences of change (Liang et al, 2012; Kusimi, 2015).

Remote sensing has been used to classify and map land cover changes with different techniques and datasets. Landsat images in particular have served a great deal in the classification of different landscape components at a larger scale (Anfuso et al, 2009). A variety of change detection techniques and algorithms have been developed and reviewed. Among these are unsupervised classification or clustering, supervised classification, principal component analysis, hybrid classification and fuzzy classification, all of which are the most commonly applied techniques used in classification (Rundquist et al, 2001; Cai et al, 2000).

Fuzzy classification was first began by Zadeh in 1965. Land cover classes are identified as fuzzy sets and pixels elements during fuzzy representation analysis. Each pixel is attached with a collection of membership classes to show the level to which the pixel belongs to certain grades

(Venkaleswaran et al, 2013). The membership value designated to each element in the set is between 0-1 where 0 stands for completely no membership and 1 represents absolute membership, therefore the degree of membership of an element is based on class characteristics. Fuzzy is applied in pattern recognition and classification, management, process control and decision making. One merit in fuzzy set is its ability to each elements membership in more categories with different degrees of membership values. Secondly, it allows the natural description of the issues in linguistic terms, rather in terms of membership between precise numerical values (Mohammadpour et al, 2015). One of the disadvantages of fuzzy classification is the challenge in analysing the performance of fuzzy supervised and unsupervised classification in multispectral images. Other limitations include; cumbersome in use, high dimensions, poor suitability to change cost matrices and lastly, the amount of information a user can bring to bear is limited as there are no positions and widths of category membership (Venkaleswaran et al, 2013).

Principal component analysis was introduced in 1901 by Karl Pearson, as an analogue of the initial axis theorem in mechanics. Harold Hotelling later independently developed and named it in the 1930's. Other areas of application call it the discrete Karhunen-Loeve transform (KLT) in signal processing. Principal component analysis is often used as a tool in visualizing genetic distance and also in exploratory data analysis for making predictive models (Adnan et al, 2013). Principal component analysis has no demerits. This is a method in which primary data is changed to another set of data which may capture germane information. Mostly some variables are highly correlated such that the data contained in one variable is basically a repetition of the information available in a different variable. Instead of deleting the redundant data, principal component analysis minimizes the information in intercorrelated variables into fragments called principal components (Mishra et al, 2017).

The combination of both the supervised and unsupervised classification is known as the hybrid system. This enables remote sensing program to classify lesser known land cover into distinct groups. This form of classification is best for identifying landscapes that has numerous land cover objects using VHSR images. However the pixel based classification of remote sensing images performed with different classifications normally produce results which vary (Goncalves, 2011).

Various supervised classification methods have been applied extensively for the land cover change analysis throughout the world. This technique depends on a combination of background knowledge and personal experience with the study area to a greater extent than other areas. Several researchers have employed this technique and achieved highly satisfactory results (Gbekor, 2008; Firdaus, 2014; Rawat et al, 2015; Rwanga and Ndambuki, 2017).

Supervised classification and unsupervised classification remain the most widely used classification methods among scholars (Auzet, 2008). The supervised classification method relies largely on the analyst's familiarity with the area of interest and availability of adequate data in order to spectrally characterize the classes by selecting pre-determined cover types known as training areas (Kerle et al, 2004). Unlike supervised classification method the unsupervised classification method makes less demand on the analyst's knowledge in portioning the image data, cluster algorithm relatively partition spectrally by determining statistical groups based on numerical information (DN values) present in the image. However the analyst is required to specify the desired number of classes in the data set and merge and split some groups in the output of the classifier. Hence unsupervised classification is not entirely independent of human intervention. Where there exist complex variability in the spectral response pattern for individual cover types as a result of variation within cover types and site conditions, both classification methods are a combined method termed as hybrid classification (Lillesand and Kiefer, 2014).

Despite the necessity for a standard classification system more of the current classification has been intentionally accepted (UNESCO, 2016) Therefore, the FAO has a new approach to classification which seeks to a more holistic way of increasing the flexibility while maintaining mapability (FAO, 2001). Also, FAO approach helps to create a standardized, hierarchical, consistent, a priori classification system containing systematic and strict class boundary definitions implies the basic requirement of having to build flexibility into the classification systems to describe enough classes to cope with the real world (FAO, 2016) At the same time, however, flexibility should adhere to strict class boundary definitions that should be unambiguous and clear (Ashton and Giosan, 2011). In addition, the classes in such a system should be as neutral as possible in the description of land feature in order to answer to the needs of wide variety of end users and disciplines (FAO, 2016).

One of the basic principles adopted in the new approach is that a given land cover class is defined by the combination of set of independent diagnostic attributes also known as classifiers (FAO, 2016). The more classifiers added, the more detailed the class is. The class boundary is then defined either by the different amount of classifiers, or by the presence of one or more different types of classifiers (Leatherman, 2010). This emphasis is no longer on the class name, but on the set of classifiers used to define this class. Application of the FAO approach is by two main factors. First is the Land Cover which describes the whole observable physical environment and therefore deals with a heterogeneous set of classes (Legal, 2012). Instead of using same set of classifiers to describe heterogenous features, in the new approach the classifiers are tailored to major land cover features. According to the general concept of a priori classification, it is fundamental to the system that all the combinations of the classifiers must be created in the system (Zaman, 2016). By tailoring the set of classifiers to the major land cover features, all combinations can be made

without having a tremendous number of theoretical but redundant combinations of classifiers (Lins and Slack, 2009). Secondly, two distinct land cover features having the same set of classifiers to describe them may differ in the hierarchical arrangement of these classifiers in order to ensure a high mapability (FAO, 2016).

2.5 Accuracy Assessment

Accuracy assessment or validation is a significant step in the processing of remote sensing data (Rwanga and Ndambuki, 2017) and perhaps the most crucial part of studying image classification and thus LULC change detection in order to understand and estimate the changes accurately (Firdaus, 2014). This method is mainly the most commonly used method for an estimation of classification approach execution and establishes the information value of the resulting data. The various statistics generated under accuracy assessment include overall accuracy, kappa coefficient, producer's accuracy and user's accuracy, commission and omission.

The overall accuracy of the classified image compares how each of the pixels is classified against the definite land cover conditions obtained from their corresponding ground truth data. In other words, it determines which proportion of the reference sites was measured accurately. The overall accuracy is often identified as a percent with 100% accuracy being a perfect classification where all sites of reference were accurately classified (Adade et al, 2017).

Producer's accuracy measures errors of omission, which is a measure of how well real-world land cover types can be classified. Producer accuracy is a map accuracy from the point of view of the map maker. It expresses how often real features on the ground are correctly identified on a classified map (Adade et al, 2017). In contrast, user's accuracy measures errors of commission,

which represents the likelihood of a classified pixel matching the land cover type of its corresponding real-world location. It is the accuracy from the point of view of a map user, not the map maker. The user accuracy essentially tells us how often the class on the map will actively be present on the ground (Ye et al, 2018).

The error matrix and kappa coefficient have become a standard means of assessment of image classification accuracy. Moreover, Error matrix have been used in numerous land classification studies and were a crucial component of this research. (Rwanga and Ndambuki, 2017).

Overall accuracy and Kappa coefficient are widely used among scholars. Whereas the estimation of the former is less rigorous and is achieved by dividing the number of correct observations by the number of actual observations (Basommi et al, 2015), that of the latter is more scientific and is obtained by the following formula

$$K = \frac{N \sum_{i=1}^r X_{ii} - \sum_{i=1}^r (x_{i+} * x_{+i})}{N^2 - \sum_{i=1}^r (x_{i+} * x_{+i})}$$

Where r is the number of rows, x_i is the number of observations in row i and column i , x_{i+} and x_{+i} are the marginal totals of row and column, and N is the total number of observed pixels (Congalton, 1991; Firdaus, 2014; Rwanga and Ndambuki, 2017). The value greater than 0.8 to 1 means there is perfect agreement; the value between 0.40 and 0.80 means moderate classification and values from 0.40 to 0 means the agreement is no better than would be expected by chance (Jensen and Di Gregorio, 2004; Firdaus, 2014).

2.6 Change Detection

Digital change detection is the process of determining and/or describing changes in land cover and land-use properties based on co-registered multi-temporal remote sensing data. The basic premise in using remote sensing data for change detection is that the process can identify change between two or more dates that is uncharacteristic of normal variation. While remote sensing has the capability of capturing such changes, extracting the change information from satellite data requires effective and automated change detection techniques (Adnan et al, 2013).

Analysis of detected change is the measure of the distinct data framework and thematic change information that can lead to more tangible discernment to underlying process involved in upbringing of land cover and land use changes (Ahmad, 2012). Change analysis of features of Earth's surface is essential for better understanding of interactions and relationships between human activities and natural phenomena. This understanding is necessary for improved resource management and improved decision making (Lu et al, 2004; Seif and Mokarram, 2012). Change detection involves applying multi-temporal Remote Sensing information to analyse the historical effects of an occurrence quantitatively and thus helps in determining the changes associated with land cover and land use properties with reference to the multi-temporal datasets (Ahmad, 2012; Seif and Mokarram, 2012; Zoran, 2006).

Monitoring land cover and land use change is based on the use of land use and land cover maps produced from multi temporal remotely sensed data. The goal of change detection is to discern those areas on digital images that depict change features between two or more imaging dates (Sadar and Hayes, 2011). It exhibit the ability to quantify the temporal effects from the multi temporal data set (Singh et al, 2008). Change detection has been an important tool in monitoring land use and land cover change and deforestation in many studies. Change detection procedures require

data set with accurate spatial registration and recorded on the same time of the year for the change to be effective. Although the list of change detection approaches is a non-exhaustive one, Singh 2008 has reduced them to two basic approaches namely, simultaneous analysis of multi temporal data and comparative analysis of independently produced classification from different dates. These approaches may be very good but in change detection there may be some weaknesses (Sorensen et al, 2013). The first approach is made up of techniques such as univariate image differencing, image rationing, vegetation index differencing, principle component analysis, change vector analysis and direct multi-date classification (Asubonteng, 2007). The output of the above change detection techniques are pixel values usually indicating qualitatively “Change or no change”. The weakness includes unclear way of setting threshold between changes and no change (McLachlan, 2015); high sensitivity to inter-image bad registration and provision of little or no information on the nature of change (Phillips and Jones, 2006). The second approach requires two or more independent classifications of satellite images (Campbell, 2012). Post classification change detection prominently stands out in the category. It is the most commonly used quantitative method of change detection (Chen, 2012). It operates on two or more independently classified images as inputs and results in change map and change matrix. The reality of detected change is dependent on the classification accuracy of the maps compared (Mertens and Lambin, 2017). However the post- classification approach provides “from-to” change information and the kind of landscape transformations that have occurred can easily be calculated and mapped (Bauer et al, 2015). Food and agricultural organisation of the United Nations successfully applied post classification change detection technique in a survey of forest cover and change process in 1990 (Phillips, 2018).

The method employed in any change detection analysis is of crucial importance. The type of method implemented can profoundly affect the qualitative and quantitative estimates of the change and the type of image processing method to adopt (Muttitanon and Tripathi, 2015).

2.6 Chapter summary

This chapter provides relevant literature upon which the whole research is positioned. It helps explain and understand land use/ land cover and its dynamics. Furthermore, it indicates changes that are occurring in the area under study. The review identified the most suitable classification and accuracy assessment methods to be used in the analysis.

The next chapter captures the framework for data analysis and research methods detailing the processes used to capture the empirical data

CHAPTER THREE

STUDY AREA AND RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the methodology that was employed for the study. It is made up of the profile of the study area, methods of collecting and analysing data.

3.2 Physical Features

3.2.1 Location

The Municipality lies within longitude 0.30°E and 1.05°E and latitude 5.45°N and 6.005°N (Ghana Statistical Service, 2013). It is located to the east of the Volta estuary about 160km from Accra (Fig.3.1). The total spatial area of the Municipality is 753.1 km^2 (Manson et al, 2013). The Keta lagoon is the largest lagoon in Ghana. The Keta Lagoon facilitates water transportation to surrounding communities and has potential for large-scale commercial farming of aquaculture. The Keta Municipality is located in a large wetland protected area of 1200 km^2 . It is a stopping point for a large number of migrating birds and provides a breeding ground for sea turtles (Ghana Statistical Service, 2013). The location of the Keta Municipality is very viable and profitable but due to the land use changes as well as erosion and flooding the quantum of fish harvesting and the migration of birds and turtles for touristic purposes have dwindled (Shick and Fluccus, 2009).

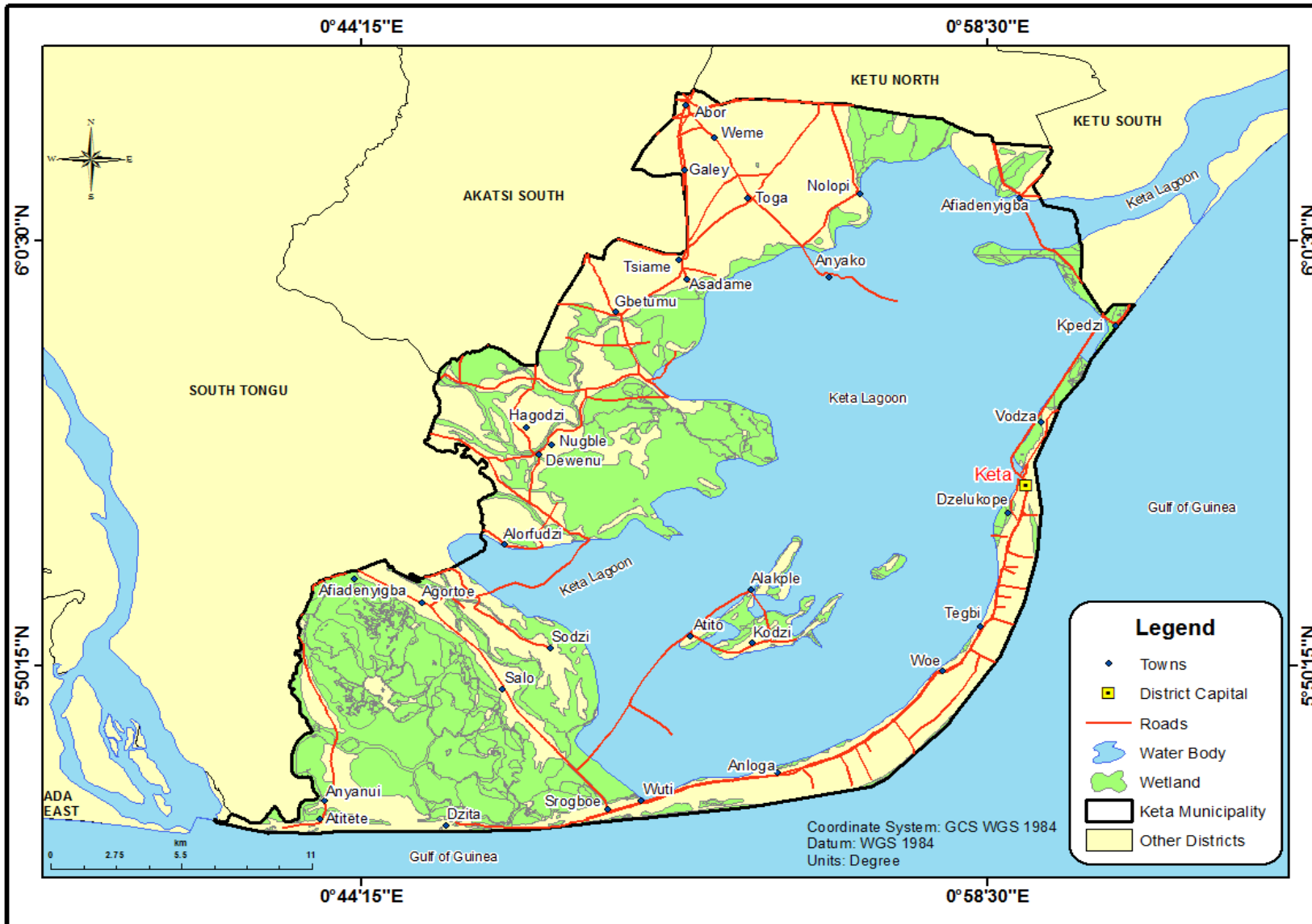


Fig 3.1 Map of Study Area

3.2.2 Geology of the area

The geology of the Keta Municipality is within the Mesozoic/Tertiary sediment basin along the Gulf of Guinea (Jorgensen and Banoeng-Yakubu, 2001). The rocks are mainly siltstones, shales and clays with layers of fossiliferous limestone, all covered by sand and gravel. It gently dips at 2° and has structures such as basin, which has tectonic block bounded by fault system at the northern end of the Keta Municipality (Akpati, 1978). Since the rocks in the Keta Municipality are predominantly sedimentary, they are porous hence their inability to hold enough water. The parent rock which is the geology is what weathers to become the soil type in the area. Since the parent material is sedimentary, the soil formed easily under goes leaching which renders the soil mostly infertile. A reduction in mangroves in the area shows a reduction in the fertility of the soil (Manson et al, 2013). The geology should therefore be considered in determining the right land use and land cover changes to maintain the landscape, the richness of the land and vegetation of the area.

3.2.3 Relief and Drainage

The Municipality is a low-lying coastal plain with the highest point of 53m above sea level and the lowest between 1 to 3.5m below sea level thereby makes it vulnerable to tidal waves and sea erosion (Lawson et al, 2012). As a result, some communities along the coast suffered sea erosion until the sea defence wall was built which has only partially solved the issues. Fig 3.1 shows that the Municipality exhibits three (3) main geographic belts namely, the plains of the north, the lagoon basin of the middle belt and the narrow coastal strip (Ghana Statistical Service, 2013).

3.2.4 Ghana Coastal Landscape

The coast of Ghana is segmented into three (3) namely; the eastern, western and central sections. The whole coast of Ghana is about 550km (Appeaning Addo, 2009). The eastern coast where the study area is located, is a sandy shoreline characterised by an eroding delta of Quaternary age (Ahmed, 2012). The Quaternary age has consolidated sediments hence makes it easier for the shoreline to retreat (Boateng, 2010). The coast of the central segment is a medium – high energy beach with rock lands and sandbars or spits surrounding the lagoons. The western segment comprises a flat and wide beach backed by a coastal lagoon and a low energy beach (Padi, 2007). Along the Ghanaian coasts, small scales of investigations have taken place at various levels, one of which conducted by Ly in 1980 on selected sites in the central, eastern and western coasts (Martin, 2011). The results indicated that generally erosion was taking place along the entire coastline of Ghana (Saka et al, 2013). Another was in 1997 where the Ministry of Works and Housing studied shoreline changes along the coast of Keta, which was part of the Environmental Impact Assessment of the Keta Sea Defence (Duodo, 2012). Appeaning Addo et al. (2008) also investigated the erosion rates and the shoreline change of about 40km of the Accra coast in detail. A study by Boateng, (2012) showed that over 107 years, a section in the eastern coast which extends 94 km long from Keta Lagoon at the east to the Gyankai lagoon at the West has lost 4,974 hectares of land according to shoreline change assessment. This implies an average loss of 46.5hectares per annum on the coastal front. On the average an estimation of about 3.9m, +/- 0.4m per annum is the rate of recession between 1895 and 2002 (Marabini, 2013); this estimation according to the same author is “ higher and significantly, variable than those previously estimated (3.0 m per year by Wellens-Mensah et al. 2002 and 8.0 m per year by Ly 1980)”.

3.2.5 Climate

The Keta Municipality lies within the dry equatorial climatic region of Ghana. It has two seasons namely the dry and the rainy season (Ghana Statistical Service, 2013). The major rainy season occurs between April and July whilst the minor one falls between September and October of every year. June is usually the wettest month in the area. Humidity values such as 96% and 63% have been recorded (Banoeng- Yakubo et al, 2005). Available data between 1913 and 1992 indicates annual precipitation is averagely 800.8mm (Appeaning Addo et al, 2008). The highest mean value is 187.5mm which occurs in June and the lowest occurs in January with a value of 10.6mm. In June, rainfall exceeds potential evaporation, as the yearly evaporation is about 1785mm (Banoeng-Yakubo et al, 2005). The climate in the Keta Municipality largely affects the geomorphic activities that influence LULC changes.

3.2.6 Vegetation

Keta Municipality falls within the coastal savanna zone which is categorized into four (4) vegetation zones (Rangel-Buitrago et al, 2015). The northern part of the Municipality is marked by tall grasses and interspersed with medium sized trees with relatively higher density; the mid-section with short grasses and short trees with occasional occurrence of “Pamira” palm and baobab trees; the south-western part, characterized by mangrove plants (white and red mangroves) along the Volta estuary and tall grasses used for fuel, and mat/hat weaving respectively and the south-eastern part along the coast from Whuti with short grasses and many neem trees (Ghana Statistical Survey, 2014).

Mangrove along the coast for instance contain resources that provide fuel wood, building materials, medical plants and shelters a wide range of edible animals and plants (Ruby et al, 2008). Mangroves are known for high biological productivity, carbon sequestration, nutrient control, ground water recharge properties and flood control (Shick and Fluccus, 2009). Mangroves are able to prevent erosion by stabilising sediments with their tangled root system and trapping sediments originating from inland (Ramachandra, 2004). The growth of mangroves is within two (2) to four (4) years. Meanwhile, the growth of mangroves is dependent on the species and the nutrients available to it (Aaviksoo, 2016). The mangroves at Anyanyui are however harvested for both domestic (such as cooking and roofing of houses) and for commercial purposes such as smoking of fish (Manson et al, 2013). The intensified harvesting of red and white mangroves growing around Anyanyui, Atorkor and Salo for domestic and commercial use have aggravated the soil erosion problem and led to the increase of coastal erosion. Complex developments prevent the coastline from adapting to increased erosion rates by shifting landward (Schleupner, 2008). In Anyanyui, there is extension marshland with limited dry land areas leading to high competition between the eroding coast and the inhabitants for this area. The large expanse of marshland could however be an advantage to mangrove migration, due to minimal competition for the land that is conducive for mangrove growth (Gable, 2017).

With higher energy wave close to the mangrove areas, sediments from the mangrove area may be washed away, as the Keta beach is generally sandy. This is because mobile sand presents less resistance to wave action (Rawat et al, 2013). The sand is easily removed from the coast and carried away by the drift. Reduction in sediment supply from other sources such as Volta River to compensate for this loss increases the risk of erosion along the coast (Boateng, 2009).

3.3 Anthropogenic Features

3.3.1 Settlement

The UN desired definition for a house is a place where an individual or a group of persons can isolate themselves from harm (UN Habitat, 2010). GSS, (2014) puts the population of the municipality at 147,168 representing 7% of the total population of the Volta region. The people of the municipality reside in apartments, detached houses, semi-detached houses, compound houses, kiosks, containers, huts and tents. It is observed that those who live along the coast where the erosion and flooding are prominent due to land use and land cover changes live in thatch houses. The twenty largest communities by population in the Keta Municipality are Anloga, Tegbi, Woe, Dzelukope, Keta, Anloga Afiadenyigba, Abor, Anyako, Dzita Agbledomi, Tsiame, Atiavi, Adzido-Vordza, Whuti, Dzita, Dzelukope, Anyanyui, Hartorgodo, Kedzi, Atorkor and Sasieme (Otoo et al, 2006).

3.3.2 Economic activities

The Keta Municipality is mainly an agricultural district but there are other small-scale businesses which are owned by sole proprietors (Kufogbe, 1997). Majority of the population are into fishing, livestock keeping, crop farming and other related activities. The industrial activities include ceramics (pottery); wood work (carpentry and standing brooms); textile (Kente weaving, tailoring and dressmaking); mining (salt and sand mining) and agro-based (fish processing, cassava processing, sugar cane juice distilling and coconut oil extraction), (GSS, 2013).

Additionally there are services which include beauticians, masonry, vehicular mechanics as well as TV/radio repairers (Kumi-Boateng et al, 2012). The economic activities of residents inform the

rate at which livelihoods are being affected by the land use changes particularly, the putting up of infrastructure. A large percentage of the working population are into farming and fishing therefore, issues of erosion and flooding are having adverse effects on the people (Ministry of Works and Housing, 1997).

3.3.4 Services

The Keta Municipality has a number of telecommunication networks as well as commercial banks and rural banks serving as financial services. The sources of transportation in the municipality are roads and water. The water transportation is privately owned. The issue of transportation is very pertinent in the municipality whiles most of the roads are being destroyed by erosion and flooding due to poor LULC activities (Ghana Statistical Service, 2013).

3.4 RESEARCH METHODOLOGY

3.4.1 Data Acquisition

The study used Landsat data of three different years covering 1991, 2005 and 2018 respectively. All the acquired data were obtained from USGS Earth Explorer (<https://earthexplorer.usgs.gov/>). There was field data collection in Keta Municipality which was later used as training sites during the classification of the acquired satellite data. Table 3.1 shows a summary of the data obtained, which comprise one Landsat Thematic Mapper 5 (LT5) data, one Landsat 7 Enhanced Thematic Mapper Plus (L7 ETM+) data and one Operational Land Imager/Thermal Infrared Sensor (Landsat 8 OLI_TIRS) data. The data was carefully selected with a cloud cover below 10% to enhance the

accuracy of the results that were obtained. The 1991, 2005 and 2018 data were all obtained in January. Other data used in the study include Ghana vector data on roads, district boundary, river body, towns and forest reserves, which were obtained from the Remote Sensing and Geographic Information Laboratory (RSGIS Lab).

Table 3.1: Landsat TM/ETM+/ used in this study.

Landsat Product	Acquisition Date	Path/Row	Spatial Resolution	Source
Landsat TM 5	4 January 1991	192/056	30m	USGS
Landsat 7 ETM+	9 January 2005	192/056	30m	USGS
Landsat 8	5 January 2018	192/056	30 m	USGS

The analysis of satellite data was subjected to thorough procedures that are summarized in the flow chart as shown in Fig 3.2.

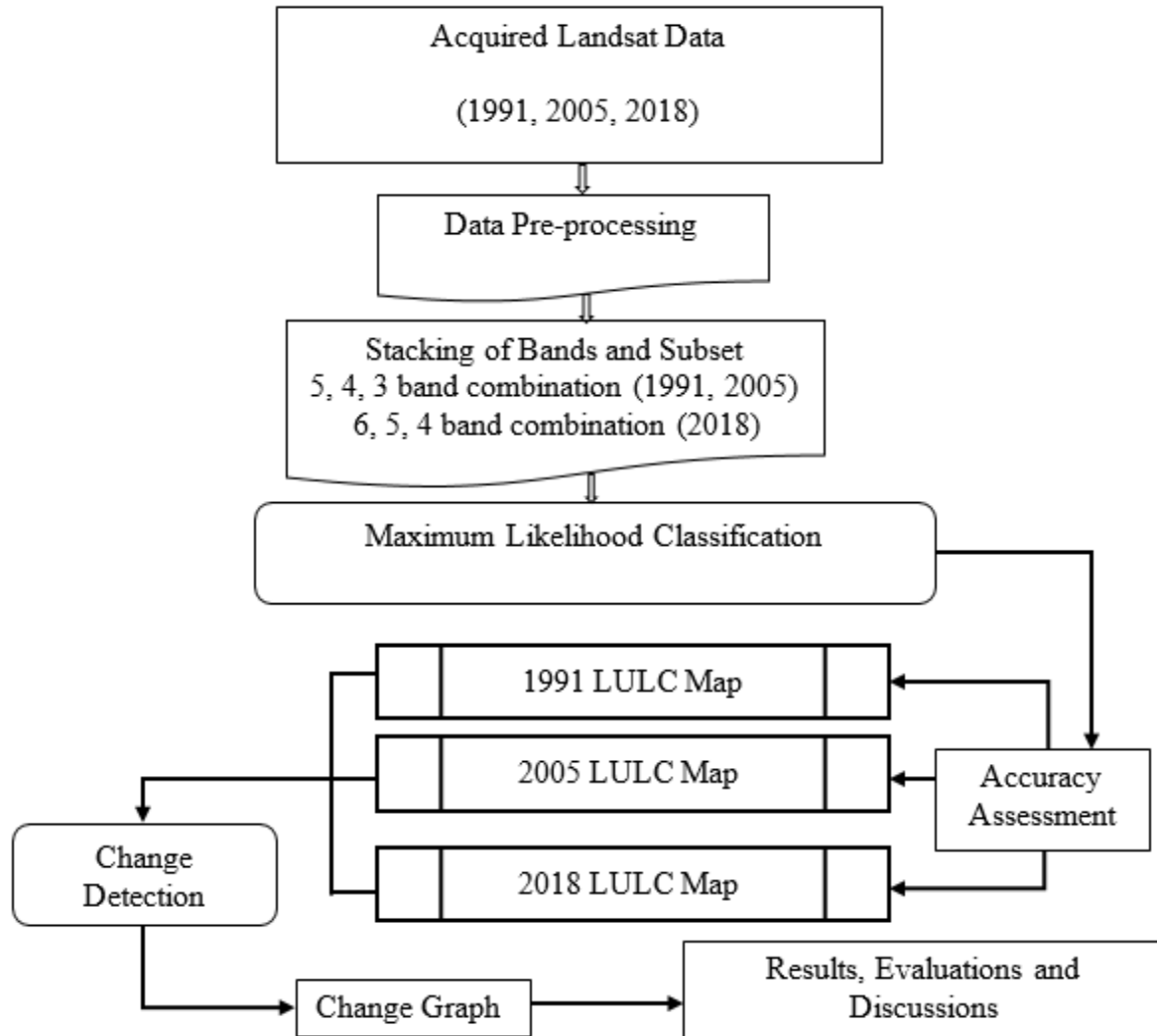


Fig. 3.2 Flow chart showing the processes used to derive the LULC in the Keta Municipality

The chart shows the series of processes that were undertaken during the studies. As indicated earlier, there was acquisition of different Landsat data products. These data were pre-processed in Envi 5.3 and classified. The results obtained from the classification formed the basis for the findings on Land use and Land cover in Keta Municipality from 1991 to 2018.

3.4.2 Data Pre-processing

3.4.2.1 Radiometric correction and scan line removal

Before the classification of the Landsat data that were used in this study, radiometric calibration was carried out in Envi 5.3 software environment. As shown in Fig. 3.3, there is a clear colour distinction between a data before calibration (a) and after calibration (b) has been performed.

It must be noted that the three Landsat data were subjected to radiometric calibration. This was done by loading in Envi 5.3, the metadata of the acquired Landsat data of the three years under study. Once the data were loaded, radiometric correction was engaged on the Multispectral bands that were automatically grouped by the software. This way, the software automatically correct the data by using the information available in the metadata. This is different from the earlier versions of Envi where the parameters needed for calibration had to be entered for each band, which made the exercise tedious and time consuming. It is important to note that before calibration was performed on 2005 data, there was a prior process called scan line removal. The removal of scan lines was performed by using an extension in Envi called Landsat_gapfill. Figure (3.3c and 3.3d) shows an instance of 2005 band before and after the removal of the scan lines.

3.4.2.2 Image subset

An important aspect of data analysis is to focus attention on the area of interest. This process can be done at any stage of the data processing. Landsat imagery cover wide areas that often go beyond the study area the researcher is interested in. Using the shapefile or vector data of Keta Municipality that was obtained from RSGIS Lab, 1991, 2005 and 2018 Landsat data were subset using Envi 5.3 to obtain the Region of Interest (ROI) also called Area of Interest (AOI). The

original data located between longitudes 0°30' E and 2°30' E and between latitudes 5°N and 6°30'N had a full extent of 1:1,590,921. After subset, this extent was reduced to 1:252,187 using Keta Municipality vector which fall between longitudes 0°40'30"E and 1°1'30"E and between latitudes 5°45'N and 6°5'N.

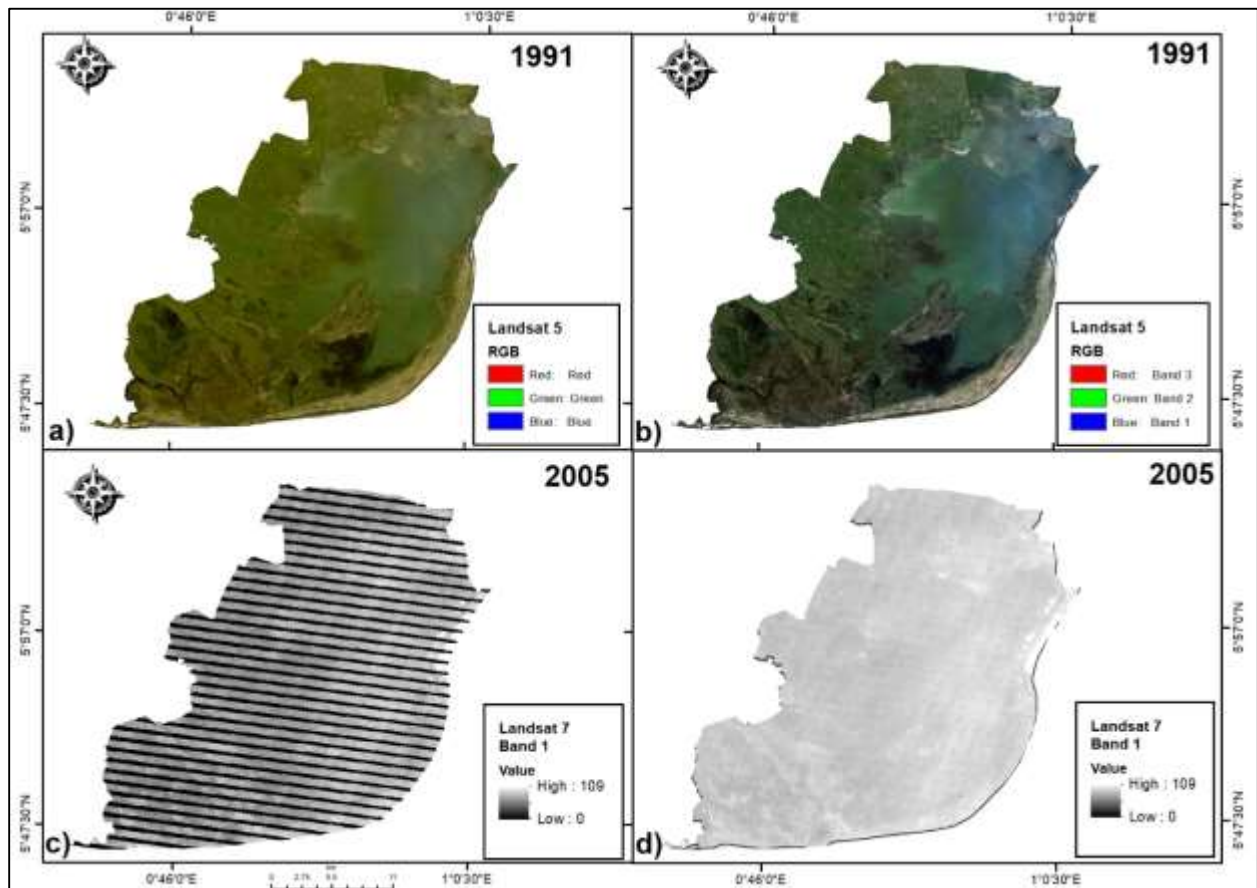


Fig 3.3: Keta Municipality. a) Landsat 5 image of Keta in 1991 before radiometric correction. b) Same image in 1991 after calibration. c) Landsat 7 image of Keta showing scan lines. d) Landsat 7 image of Keta after the scan lines were removed.

3.4.2.3 Layer Staking

This is an important stage of the pre-processing stage. Layer stacking as the name suggest deals with the combination of satellite bands. Because bands are captured at different wavelengths, their combinations produce different colour renditions depending on the arrangement of the bands. For Landsat 5 and Landsat 7, band 3 is represented by red; band 2 is green and band 1 is blue. The combination of these three bands in the order 3-2-1 will produce a true colour image as perceived by the human eye. However, this colour combination is not always efficient during classification. Any other band combination is known as false colour. Different studies require different band combinations so, for the purpose of this study and after taking into consideration the landscape of Keta Municipality, band combinations 5, 4, 3 were used for 1991 and 2005 imageries with the equivalent in Landsat 8 for 2018 data being 6, 5, 4. Figure 3.4 shows the false colour imagery obtained.

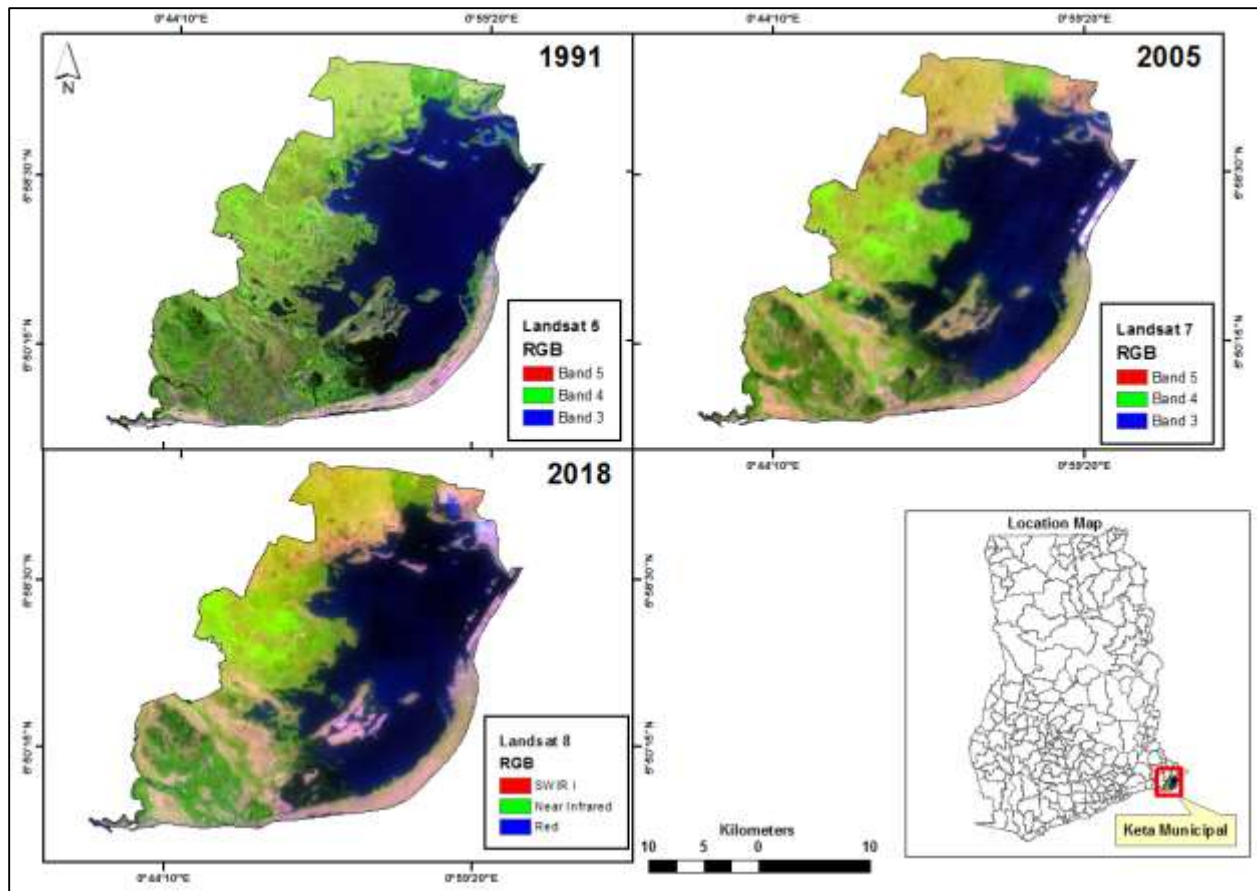


Fig 3.4: Keta Municipality shown in band combination 5, 4, 3 and 6, 5, 4

3.4.3 Landsat data Processing

Based on the layer stacking that was previously executed, together with the field data collected, the researcher settled on supervised classification because it presented more advantage over the unsupervised classification which is solely determined by the software (Bolleta et al, 2006). The classification scheme that was used is presented in Table 3.2.

Table 3.2: Classification Scheme

Classes	Description
Water	Include all water bodies in Keta Municipality with emphasis on the Keta Lagoon
Wetlands	Include swamps and marshes around water bodies
Grasslands	include all sparse vegetation other than agricultural fields and wetlands
Farmlands	Include all agricultural fields
Bare Lands	Recently cleared farmlands, untarred roads, mining sites and barren lands
Built-up Area	Dense infrastructural areas, well laid out with little or no vegetation. Paved roads

The researcher ran the supervised classification in Envi 5.3 using Maximum Likelihood Algorithm, a statistical decision rule that examines the probability function of a pixel for each of the classes and assigns the pixel to the class with the highest probability (Firdaus, 2014). As shown in Fig 3.5, Google Earth was essentially used to validate the colour interpretation.

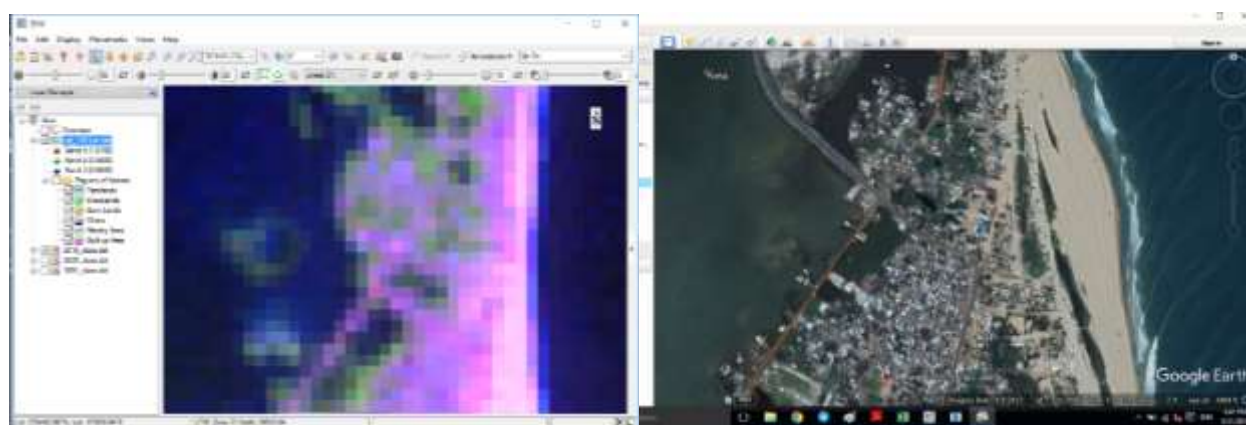


Fig 3.5 Identification of training sites using Landsat image (Envi 5.3) on the left, and Google earth on the right.

3.4.4 Change Detection Statistics between 1991 and 2018

This is an automated procedure which consists of using the classified data of the initial year under study against the classified data of the final year (Congalton and Greek, 2009). The software then generate the change detection matrix which shows the classes that have reduced and those that have increased over a giving period of time (Hamilton et al, 2011). The areas of the classes identified were calculated based on the classification statistics that were generated for each classified image (Collins and Evans, 2017). Landsat image resolution is 30m * 30m for each pixel; this means the area of each pixel is 90 m². This is equivalent to 0.0009 km² (Brunel and Sabatier, 2009). Therefore, using this background information the researcher was able to arrive at the actual area of the Study Area by aggregating the total number of pixels of all the identified classes.

3.5 Chapter Summary

This chapter in summary gives a focus as to which direction this research is headed. The various methodologies all link to each other. It detailed the research methods to be used to capture data empirically as well as the techniques for data collection, the strategy for research and the various frameworks and flow charts for data analysis.

CHAPTER FOUR

FINDINGS

4.1 Introduction

The first section of this chapter is dedicated to the results on LULC types identified in Keta Municipality and the changes that have occurred in the Municipality from 1991 to 2018 among the LULC. The second section provides a thorough discussion on LULC dynamics in Keta Municipality.

4.2 Accuracy Assessment

A laydown procedure in ArcMap 10.4 was followed to generate a confusion matrix for the three classified images. With the exception of 1991 and 2005 whose 250 validation samples each were collected from historical data on Google earth, a total of 250 validation samples were collected from 2018 field survey for assessment. Below are the steps involved:

Firstly, identifying ground truth points or reference points. Secondly, the conversion of ground truth points from vector to raster data. This is followed by merging of the raster data and the classification of the image, the last process is the creation of confusion matrix.

Table 4.1 Error Matrix for 2018 classification

Classified	Water	Bare Lands	Wetlands	Built-up Area	Farmlands	Grasslands	Classified Total
Water	44	0	0	0	0	0	44
Bare Lands	0	44	0	0	1	0	45
Wetlands	0	0	40	0	0	0	40
Built-up Area	6	1	0	40	0	0	47
Farmlands	0	0	0	0	39	0	39
Grasslands	0	0	0	0	0	35	35
Reference Total	50	45	40	40	40	35	250

The study focused on determining the kappa coefficient and overall accuracy to ascertain the reliability of the classified Landsat imageries used.

Thus applying equation (1), the resultant kappa coefficient would be as

$$K = \frac{(250 * (44 + 44 + 40 + 40 + 39 + 35)) - ((44 * 50) + (45 * 45) + (40 * 40) + (47 * 40) + (39 * 40) + (35 * 35))}{250^2 - ((44 * 50) + (45 * 45) + (40 * 40) + (47 * 40) + (39 * 40) + (35 * 35))}$$

K=0.96

The overall accuracy (OA) is generated by simply dividing the correctly classified pixels over the total number of sampled pixels.

$$OA = (44+44+40+40+39+35)/250$$

$$OA = 0.97$$

The results in the Table 4.2, 4.3 and 4.4 not only present the overall accuracy and kappa coefficient but also the producer's accuracy and user's accuracy of the classification for the years 1991, 2005 and 2018 respectively.

Table 4.2: 1991 Confusion Matrix

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Overall Accuracy	Kappa Coefficient
Built-up Area	40	47	40	100%	85.10%	0.81	0.77
Wetlands	40	35	32	80%	91.42%		
Water	50	53	45	90%	84.91%		
Bare Lands	45	29	25	55.56%	86.21%		
Grasslands	35	27	25	71.43%	92.59%		
Farmlands	40	59	36	90%	61.02%		
Total	250	250	203				

Table 4.3: 2005 Confusion Matrix

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Overall Accuracy	Kappa Coefficient
Water	50	50	50	100%	100%	0.98	0.97
Bare Lands	45	47	45	100%	95.74%		
Wetlands	40	41	39	97.5%	95.12%		
Grasslands	35	33	33	94.29%	100%		
Built-up Area	40	40	39	97.5%	97.5%		
Farmlands	40	39	38	95%	97.44%		
Total	250	250	244				

Table 4.4: 2018 Confusion Matrix

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy	Overall Accuracy	Kappa Coefficient
Water	50	44	44	88%	100%	0.97	0.96
Bare Lands	45	45	44	97.78%	97.78%		
Wetlands	40	40	40	100%	100%		
Built-up Area	40	47	40	100%	86.11%		
Farmlands	40	39	39	97.5%	100%		
Grasslands	35	35	35	100%	100%		
Total	250	250	242				

Since $0.96 > 0.80$ and closer to 1, the classification performed on 2018 was largely accurate and reliable. The 1991 and 2005 images were associated with kappa coefficients of 0.77 and 0.97 respectively (Tables 4.2 and 4.3). This also means the classifications performed on these images were accurate and reliable in spite of the fact that the reference points were selected arbitrarily.

4.3 Land Use and Land Cover in Keta Municipality

Water, the class representing lagoon and its estuaries as well as inland streams that are not covered by vegetation, stood as the most dominant LULC type in 1991 in Keta Municipality with a surface area of 267.51 km². As such it represented 36% of the surface area of Keta Municipality. The second dominant LULC type was wetlands covering 182.33 Km², representing 24% of Keta Municipality landmass as shown on Fig 4.2.

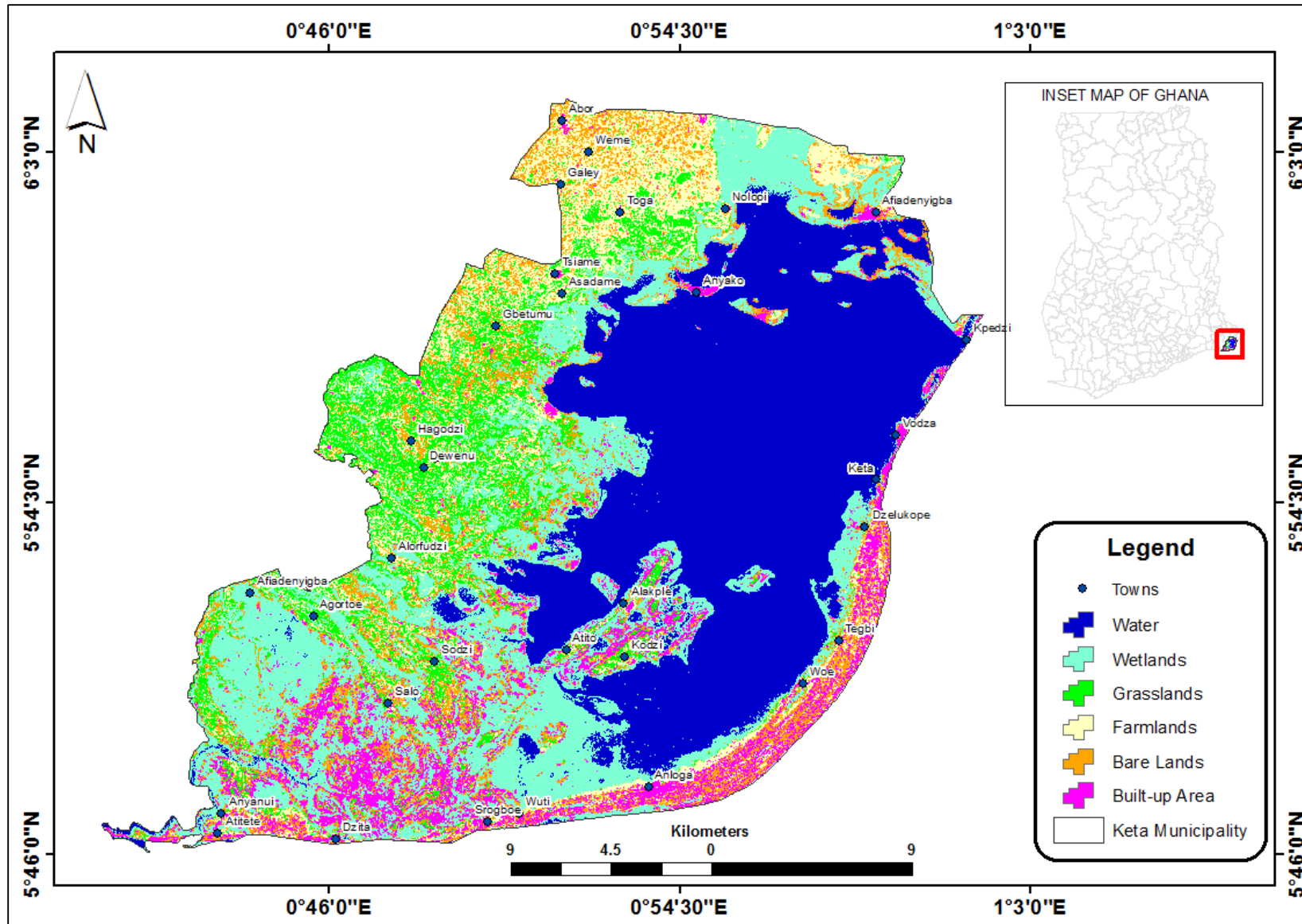


Fig 4.1 Classified Landsat TM 1991 image of the Keta Municipality

The other LULC types which were less dominant include farmlands occupying 87.24 km², bare lands with 80.59 km², grasslands with 78.53 km² and built-up area being the least LULC type with 57.02 km² of the classified pixels representing 12%, 11%, 10% and 8% respectively.

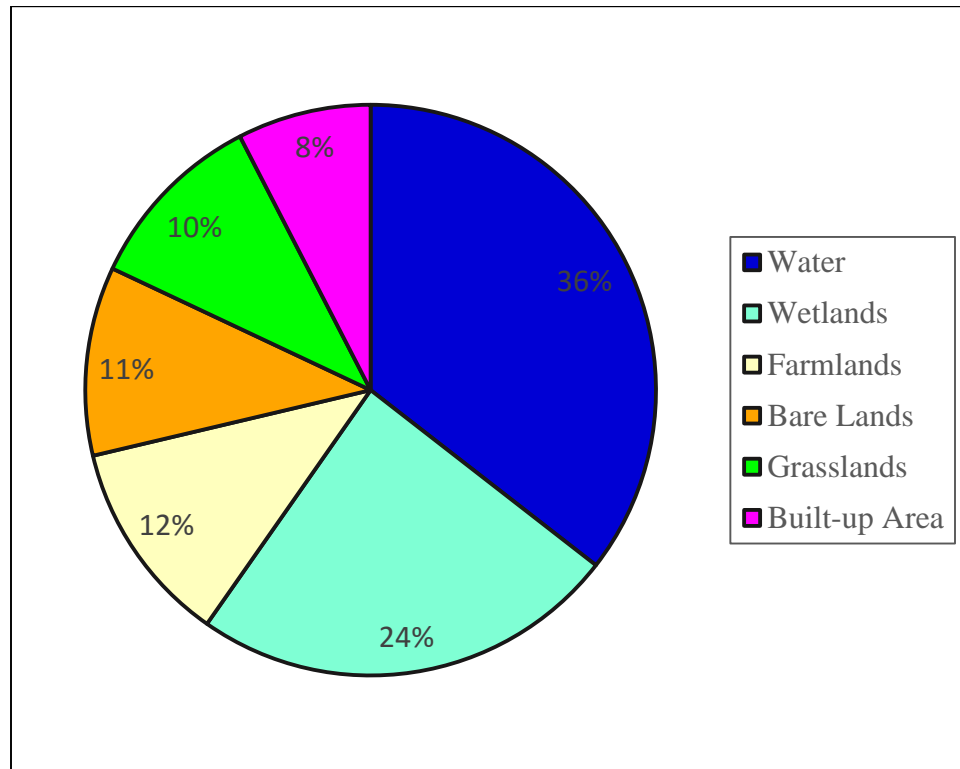


Fig 4.2 LULC types in the Keta Municipality (1991). Source: classified Landsat TM 1991 Imagery

In 2005, based on the classified pixels, it was realised that both water and wetlands remained the two most dominant LULC types in the municipality. However, both recorded surface area loss with wetlands experiencing the highest reduction, covering 117.68 km² and representing just 16% of the total landmass of Keta Municipality. The surface area of water was 258.53 km². Farmlands, grasslands, built-up area and bare lands gained all from the loss registered by the two other LULC.

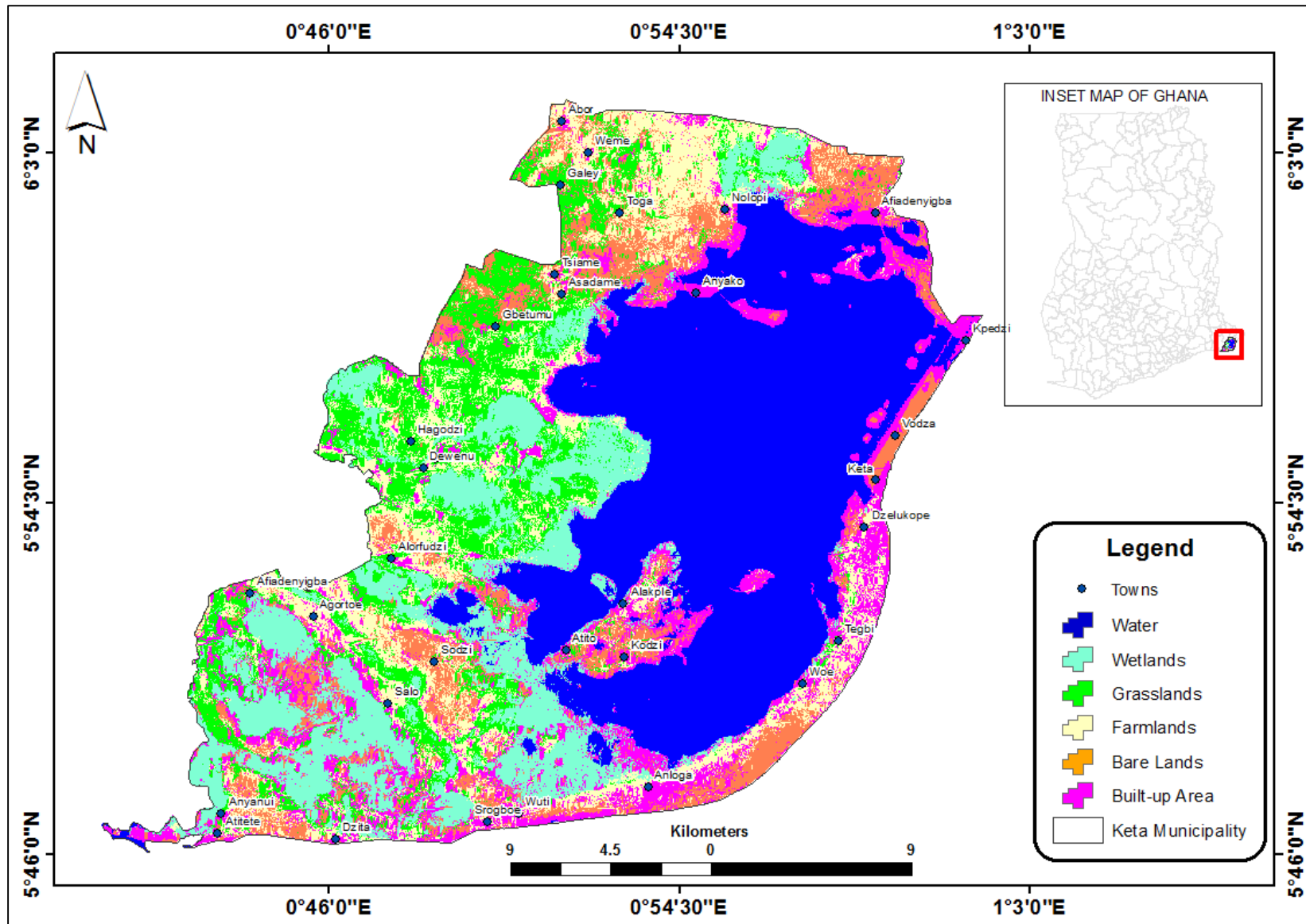


Fig 4.3 Classified Landsat ETM+ 2005 image of the Keta Municipality

However, bare lands became the least LULC type covering 81.74 km² while still maintaining 11% of the Keta Municipality landmass (Fig 4.4). Farmlands increased to 104.45 km² (14%), followed by grasslands with 99.80 km² (13%) and built-up area with 91.01 km².

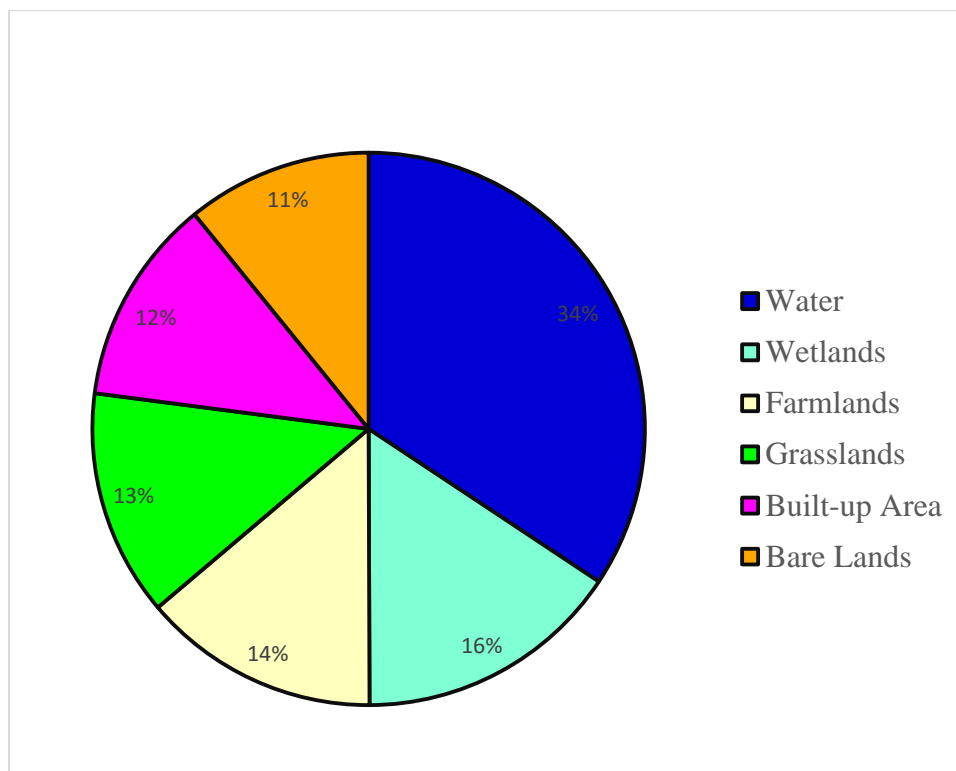


Fig 4.4 Major LULC types in the Keta Municipality (2005). Source: classified Landsat ETM+ 2005 Imagery.

The classification of 2018 Landsat 8 Imagery revealed that water remained the most dominant LULC type, covering 282.01 km². This indicates that the surface area of water was above both 1991 and 2005 figures. Unlike water, wetlands with a surface cover of 135.11 km² lost its dominance to farmlands which increased to 176.45 km². Bare lands and built-up area reduced in 2018 and stood at 76.90 km² and 71.60 km² respectively.

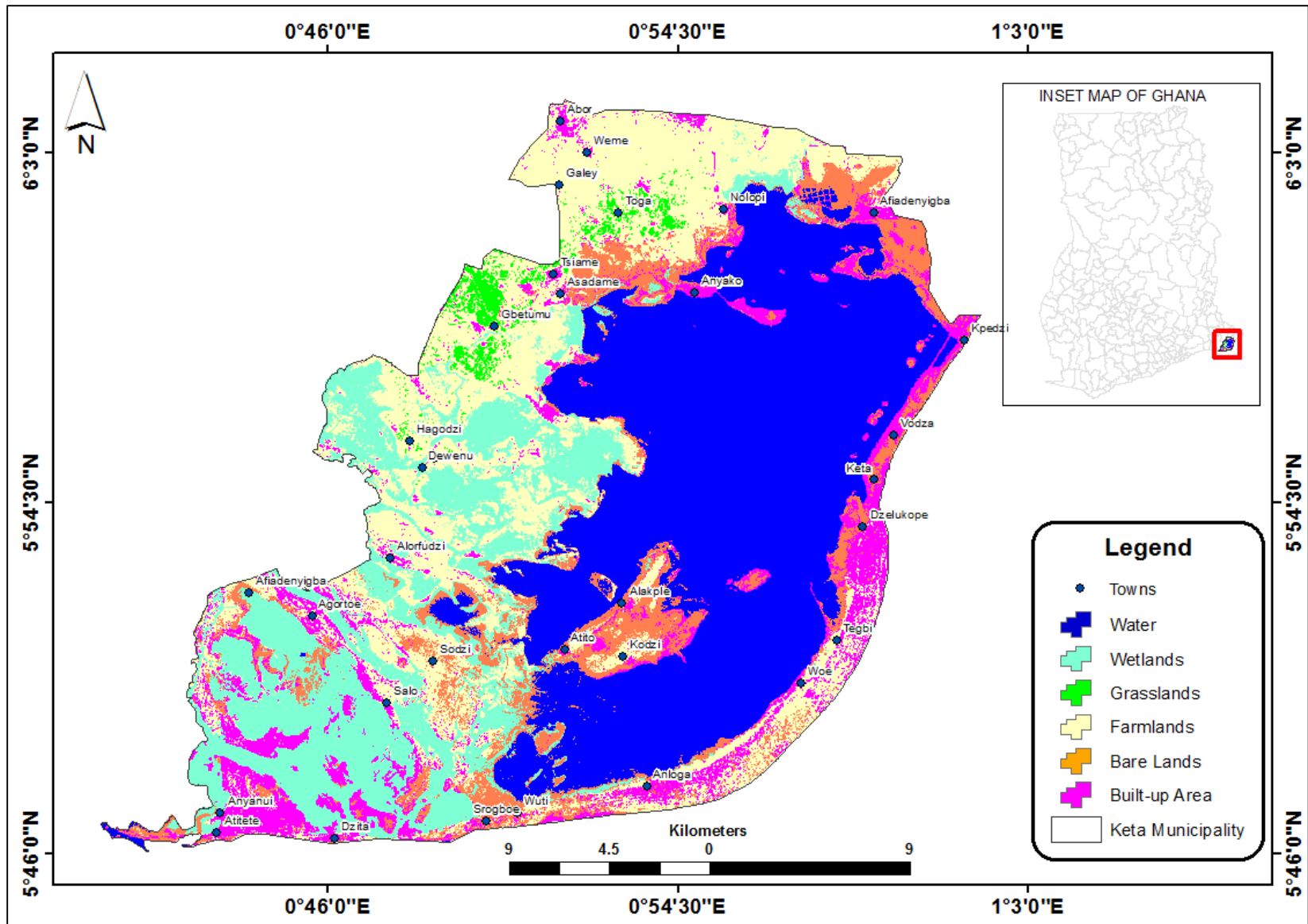


Fig 4.5 Classified Landsat 8 2018 image of the Keta Municipality

Fig 4.5 showed that grasslands have mostly been converted to the other LULC types especially into farmlands. Its cover has 11.16 km² represented only 1.48% (Fig 4.6) of the surface area of Keta Municipality.

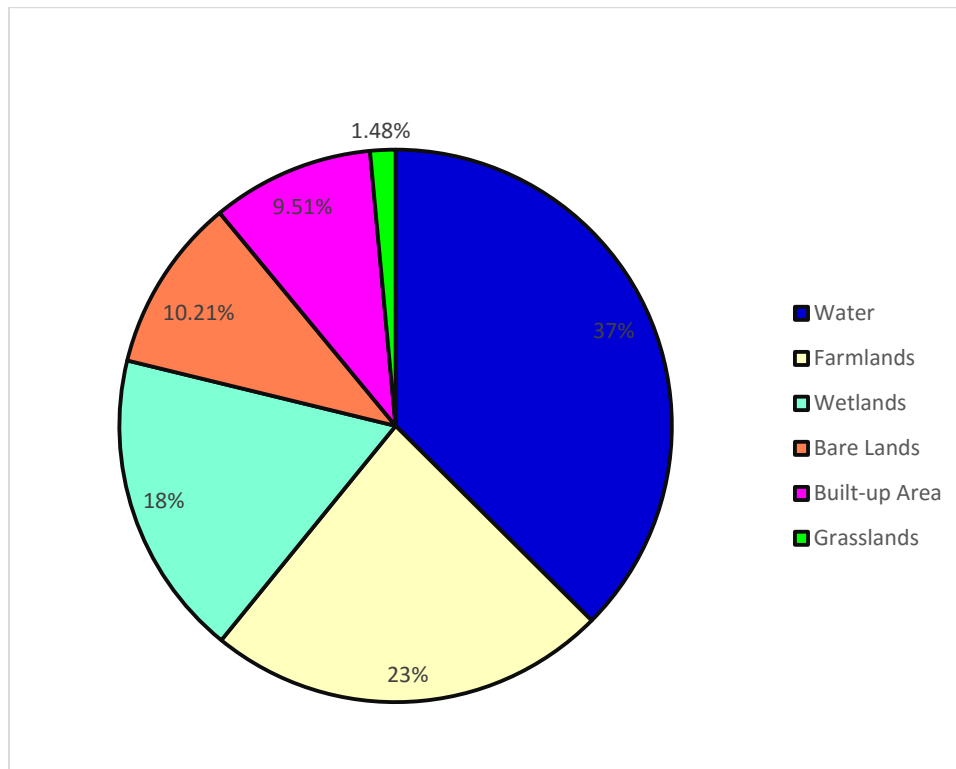


Fig 4.6 Major LULC types in the Keta Municipality (2018). Source: classified Landsat 8 2018 Imagery.

4.4 Change Detection in Keta Municipality

To better understand the changes that have taken place in the Keta Municipality from 1991 to 2018, the change detection matrices as presented in Tables 4.5 and 4.6 reveal the breakdown of the LULC types in the Keta Municipality.

Table 4.5 Change Matrix of LULC in the Keta Municipality between 1991 and 2005 in km²

		1991 FINAL STATE (KM ²)						Row Total
		Water	Bare Lands	Wetlands	Grasslands	Built-up Area	Farmlands	
2005 FINAL STATE (KM²)	Water	248.36	0.35	9.08	0.02	0.66	0.06	258.53
	Bare Lands	3.17	16.64	18.66	11.43	13.32	18.52	81.74
	Wetlands	5.89	8.26	76.52	10.14	11.40	5.48	117.68
	Grasslands	0.05	18.25	28.55	28.27	3.69	20.98	99.80
	Built-up Area	9.85	16.15	30.34	5.53	19.41	9.73	91.01
	Farmlands	0.19	20.92	19.18	23.15	8.54	32.47	104.45
	Class Total	267.51	80.59	182.33	78.53	57.02	87.24	
	Class Changes	19.15	63.94	105.82	50.26	37.61	54.77	
	Image Difference	-8.98	1.16	-64.65	21.27	33.99	17.21	

Source: Change Detection Results, 2018

Table 4.6 Change Matrix of LULC in the Keta Municipality between 1991 and 2018 in km²

		1991 FINAL STATE (KM ²)						Row Total
		Water	Bare Lands	Wetlands	Grasslands	Built-up Area	Farmlands	
2018 FINAL STATE (KM²)	Water	254.26	0.75	25.94	0.01	1.00	0.05	282.01
	Bare Lands	6.92	11.97	37.03	4.51	10.79	5.68	76.90
	Wetlands	0.83	14.45	73.66	20.60	16.86	8.71	135.11
	Grasslands	0.00	2.08	0.16	4.26	0.05	4.61	11.16
	Built-up Area	5.47	14.74	16.90	6.67	17.03	10.77	71.59
	Farmlands	0.02	36.59	28.66	42.48	11.28	57.43	176.45
	Class Total	267.51	80.59	182.33	78.53	57.02	87.24	
	Class Changes	13.24	68.62	108.68	74.27	39.98	29.82	
	Image Difference	14.50	-3.69	-47.22	-67.37	14.58	89.21	

Source Change Detection Results, 2018

In 2005, it is observed the highest loss incurred by water was to built-up area, with a surface cover of 9.85 km². Similarly, with a surface area of 30.34 km², wetlands lost to built-up area more than any other LULC type. These gains by built-up area could explain the surge in settlements that were characteristic of 2005 classified results. In contrast, there was potential flooding and erosion evidence that areas formally occupied by built-up areas were taken over by wetlands and bare lands. They account for 11.40 km² and 13.32 km² of the loss incurred by built-up areas. Wetlands are essentially areas permanently or seasonally inundated by water, it is therefore possible the surface area they grabbed from built-up areas were through flooding. In the same vein, the transformation of built-up areas to bare lands could be explained by the coastal erosion. There were less built-up areas in 2018 than in 2005. The image difference for built-up areas in Table 4.6 was 14.8 km², lower than 33.99 km² that was observed in 2005. Again, flooding in the municipality could be said to account for this reduction especially when in 2018, there was a surge in water of up to 14.50 km² coupled with 16.86km² of built-up areas to wetlands.

Keta Municipality is mainly an agrarian economy. It is not surprising farmlands were the third most dominant class in 1991 after water and wetlands. Increase in population (Table 4.7) and improvement in agricultural practices have created a favourable ground for agricultural expansion in the Municipality. In Keta Municipality, the reduction in grasslands is mainly as the result of the expansion in farmlands. In 2005 and 2018, it was observed that farmlands gained more from grasslands and wetlands than it lost to them.

Water as LULC forms substantial part of the Municipality, and together with the sea, it constitutes one of the major causes of flooding and erosion. An increase in the surface area of water could

have a devastating effect on the surrounding floodplains of Keta Municipality. As shown in Tables 4.5 and 4.6, water has majorly gained from wetlands; 9.08 km² in 2005, and 25.94 km² in 2018. While this may not necessarily be harmful to the municipality since wetlands are known to be flood retention basins (Adade et al, 2017), the conversion of built-up areas into wetlands and vice versa is increasingly subjecting the municipality to flooding.

Since 1991, grasslands were found all the way from Anyanui in the south to Weme in the north-western stretch of the Keta Municipality (Figs 4.5 – 4.6). In 2018, they drastically reduced and are only found in patches around Gbetumu and Toga. The loss is primarily due to expansion of agricultural activities. In 2018 for instance grasslands lost 42.48 km², almost double that of 2005 figure. The threat to grasslands in the municipality is a major concern because it could lead to climate change, the loss of biodiversity and increase the possibility of flooding and erosion.

Bare Lands were found to be relatively stable in the Keta Municipality based on the classification analysis performed. In 2005, as presented in Table 4.5, bare lands lost primarily to farmlands (20.92 km²) and gained more from wetlands (18.66 km²). The same pattern is observed in 2018.

Generally, wetlands have reduced in Keta Municipality since 1991. Over 47 km² of its surface areas were lost to the other LULC types.

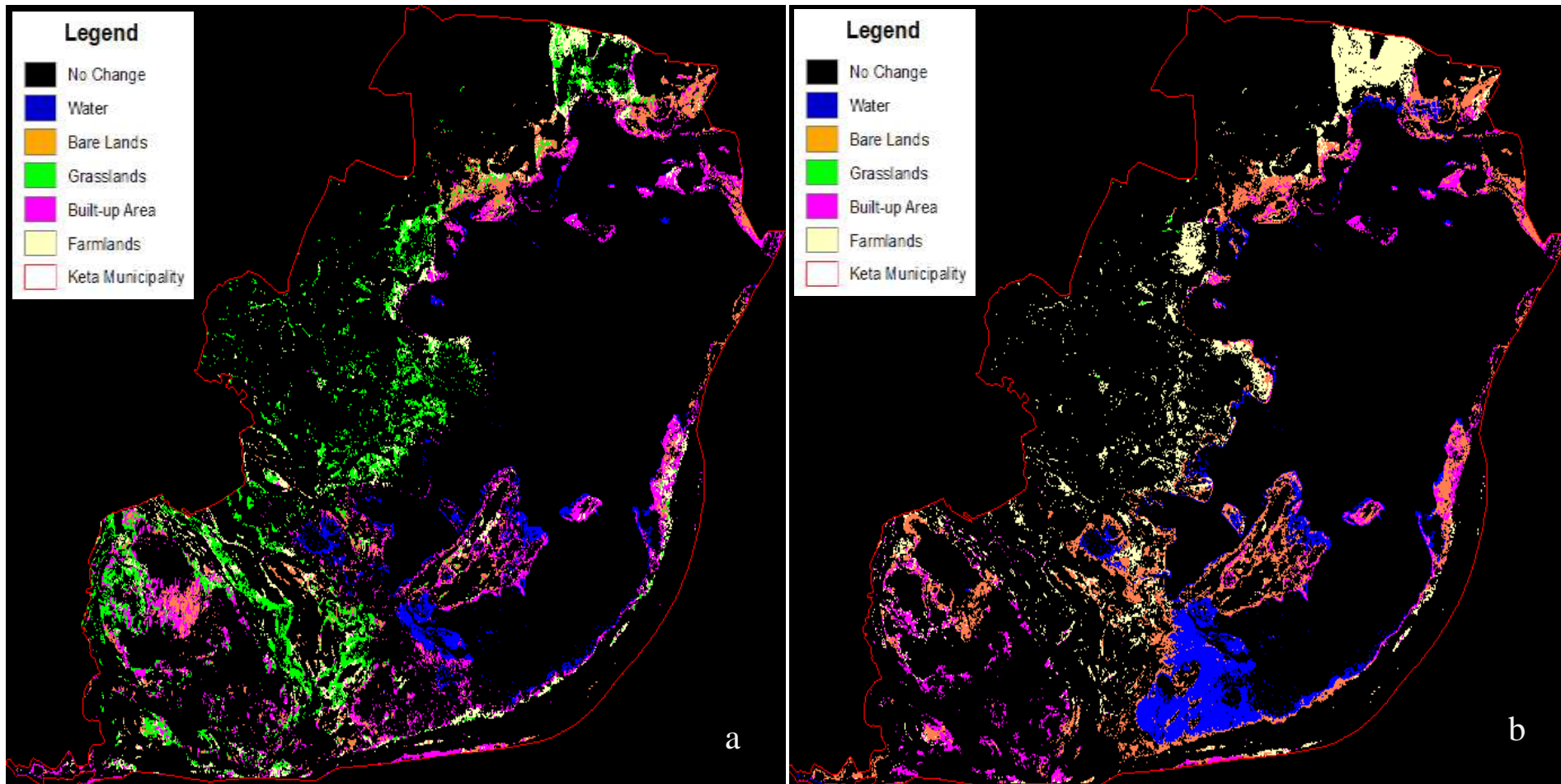


Fig 4.7: Wetlands Change in Keta. a) 1991 to 2005. b) 1991 to 2018.

In 2005, as shown in Fig 4.7, the classes identified indicate areas that were wetlands and have been converted. In Fig. 4.7 a, pixels that represented wetlands were mostly converted into grasslands. However, in 2018 more of the loss of wetlands was attributed to water. It has been established that wetlands were under the control of the communities and individuals (Kumi et al, 2016) and with no clear-cut policies, the destruction of this LULC, evidenced by the down trend from the classification results would continue and potentially increase floodings and erosion in the Municipality. The “no change” indicates areas that did not undergo any change within the period of 1991 to 2005 and 1991 to 2018.

4.5 Discussion

Keta Municipality presents a unique landscape comprising of wetlands, the largest lagoon in Ghana and a distinctive biodiversity. Yet, the landscape of the Municipality is changing natural and human induced forces such as sea level rise, flooding and coastal erosions, erection of settlements, agriculture etc. As reported by Kusimi, (2015), most land cover modification and conversion is now driven by human use rather than natural change. Since humans are at the centre of the changing environment, evaluation of land use land cover changes could be considered as the key to understanding any complex landscape and provide experts with the best engineering solutions for a sustainable management of resources (He et al, 2013).

The classification results that were obtained revealed the LULC dynamics that occurred in Keta Municipality from 1991 to 2018. One striking land cover in the municipality is its lagoon which is the largest lagoon in Ghana and is about 12 km at its widest section and 32 km long (GSS, 2014; Nortsu, 2018). Classified as water, it was observed that this LULC remained the dominant class in

the Municipality, increasing from 36% in 1991 to 37% in 2018 (Figs 4.2 and 4.6). The increase in surface area for water can be a major concern to communities living along the lagoon. One of such concerns can be primarily attributed to the reduction in wetlands in the Municipality. Fig 4.8 shows that although wetlands recovered in 2018, the coverage area was still below the recorded area in 1991. Gulbin et al, (2019) indicated that one of the important ecosystem services of wetlands is flood control. In this respect, the wetlands are long known to “act like a sponge” reducing the peak water surge. As identified by Kumi et al, (2016) and cited in Asante et al, (2017), in Ghana, mangrove land holdings mostly fall within community or individual control, and as such they have been used to satisfy several societal needs, resulting in massive degradation. The exploitation of these resources result in the reduction of wetlands which may lead to increasing surface run off. The thematic map of 1991 revealed that most of the wetlands around Wuti in the southern part and around Dzelukope in the western of Keta Municipality have been claimed by the Keta Lagoon in 2018.

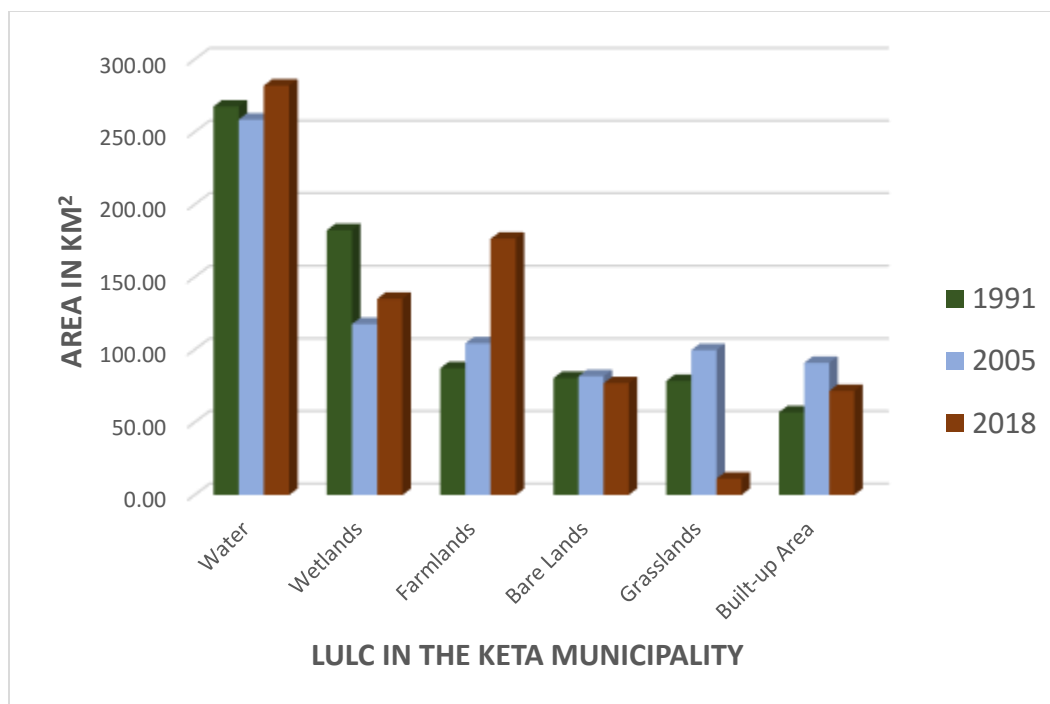


Fig 4.8 Coverage of land use/land cover types in 1991, 2005 and 2018

There is a striking rise of farmlands in the Municipality. This LULC has seen a steady increase since 1991, from 87.24 km² to 135.11 km² in 2018. In 1991, farmlands were essentially concentrated in the northern part of the Municipality and a clearly demarcated stretch from Srogboe to Anloga and Woe. In 2005, there was a major extension in farmlands all over the Municipality with noticeable conversion of wetlands and grasslands into agricultural lands. In 2018, farmlands became the second dominant LULC.

The surface area of bare lands was 80.59 km² in 1991. In 2005, it increased to 81.74 km² and reduced to 76.90 km² in 2018. These figures demonstrate the relative stability of bare lands in Keta Municipality over the period. However, same cannot be said of built-up areas. In 1991, this LULC type registered a surface area of 57.02 km² which increased to 91.01 km² in 2005. By 2018, there was a reduction of over 19 km². The increase in built-up area is a sign of urban expansion which

is manifested in the population growth in the Keta Municipality. The projected population of the Municipality according to GSS, (2019) is 182,409 whereas in 2010, the Population and Housing Census (PHS) conducted by GSS, showed the total population of the Municipality was 147,618. Earlier in 1984, the population was 137,751 (Table 4.7).

Table 4.7 Population Trend of Keta Municipality

Year	population
1984	137,751
2010	147,618
2018 (P)	182,409

Source: GSS, (1984); GSS, (2019); MoFA

This increase in population is met by the expansion of settlements, the most prominent of which are located along the coast and include Anloga, Tegbi, Woe, Dzelukope, and Keta. Keta Municipality has been saddled with series of flooding and coastal erosion, both of which destroy many homes and properties mainly due to the exposure to tidal waves and torrential rainfalls. For instance in 2016, Myjoyonline.com reported how strong waves displaced communities along the littoral of Keta Municipality. In October 2018, Modernghana.com reported that over five thousand residents within and around the Keta Municipality were rendered homeless due to floods caused by an overflow of the Keta Lagoon. These persistent occurrences may explain why in 2018, there was a reduction in built-up area in the Municipality.

The classification results showed that grasslands have experienced drastic change in Keta Municipality. This LULC type as defined in this study is the type of vegetation mainly made of grasses with scattered trees and scrubs. In 1991, the size of grasslands was 78.52 km²; it shot up

to 99.82 km² by 2005 but by the year 2018, only 11.16 km² occupied the landscape of the Municipality. This reduction could be attributed to the expansion of agricultural lands in the Municipality, from 87.24 km² to 176.45 km² by the year 2018. This notwithstanding, the other LULC types with the exception of water, have also contributed to the decline of grasslands.

In the case of Keta Municipality, there was evidence that wetlands have reduced since 1991. Literature revealed that wetlands, particularly those in the coastal savanna zone of Ghana, have become more vulnerable as a result of increasing human use such as reclamation for residential and industrial purposes (Adade et al. 2017). They were traditionally managed by small coastal communities at a sustainable level, but their intense exploitation has led to an ever-worsening picture (Vanucci, 2004; Asante, 2017). Agyeman et al, (2007) indicated that it is common to see people converting wetlands previously supporting mangrove vegetation to other uses such as rice farming and salt mining. Particularly, salt mining come along with the dredging of water, thus exposing pockets of bare lands. This unprecedented natural resources degradation and depletion at both global and national levels prompted Ghana to ratify many conventions relating to environmental sustainability (Hendriyono et al, 2015). At the international level, the country ratified for example, the Ramsar Convention in 1988, leading to the designation of the Keta Lagoon Complex and Songor Ramsar Sites, and subsequently enacted the Wetlands Management (Ramsar sites) Regulations 1999 (Asante et.al., 2017). Yet, based on the result from this research, wetlands which represented 24.21% of the Keta Municipality in 1991 reduced to 17.94 % in 2018. This demonstrate that the classification of Keta Lagoon Complex as protected area and managed by the Wildlife Division of the Forestry Commission and the awareness creation of the importance of mangrove conservation and mangrove restoration have largely failed to improve the

conservation and sustainable use of mangroves (Kirschbaum and Hetlinger, 2015). One of the key factors identified for hampering the restoration of wetlands in Keta Municipality and in Ghana in general is the land tenure system. The tenure system existing in Keta Complex Ramsar site generally is the customary tenure system which is based on the traditions of the local people (FAO, 2006; Asante et al, 2017). Kusimi, (2008) is of the view that this cultural system of land ownership strongly influences the rate of land degradation.

In the 20th century, the conversion of wetlands to other land uses, primarily agriculture, has accelerated (Gulbin et al, 2019). The expansion of agricultural lands in Keta Municipality seems to give credence to the assertion by Gulbin et al, (2019). Agricultural land use has been found to be one of the leading causes of land degradation and deforestation. The classification results from this study revealed how the surface area of farmlands doubled in 2018 from 11.58% in 1991. Increase in agricultural lands is directly linked to population growth (Lambin and Giest, 2006). As new settlements are being created, the natural vegetation, already sparse in nature are being cleared to pave way to both settlements and farmlands. This confirms the findings by Gibs et.al (2010) that in Africa, 65% of the new agricultural lands come from intact forest, 35% from disturbed forest and 5% from shrubs. In the study area, between 1991 and 2018, close to 70% of grasslands and wetlands combined were converted into agricultural land. This has serious implication for the natural vegetation because uncontrolled expansion of agricultural land coupled with unsustainable farming practices give rise to irreversible land degradation, deforestation, soil erosion and wind erosion, climate change, flooding and loss of biodiversity (Kathresan and Rajendran, 2013). This corroborates Max Planck Institute for Meteorology (2010) assertion that the natural vegetation in many parts of the world has been replaced by cropland and pastures. This has serious implications for the climate. Agricultural activities in themselves are not a nuisance for without them there will

be food insecurity, however the transformation of hitherto natural vegetative cover into agricultural lands at an unsustainable level leaves much to desire and will create serious climatic problems in the long run if not checked.

Coastal erosion and recurring flooding are common in the Keta Municipality. Scholars have studied these phenomena; government initiatives such as the Keta sea defence have been carried out yet the municipality continue to battle with floods and erosion. This study established how wetlands which naturally act as flood control agents were giving way to farmlands. Nortsu, (2018) posited that erosion is intensive and this has led to silting of lagoon beds, raising of lagoon beds and consequent flooding at the least opportunity given that there is a heavy down pour or steady rainfall over some hours. The widespread expansion of farmlands in the municipality is a potential trigger to soil erosion. This is because when the vegetation cover is removed, there is erosion, which is followed by an increase in run-off and evaporation (Agyapong-Afrifah, 2013).

4.6 Chapter Summary

This chapter presented the results based on the classification of the various Landsat imageries that were downloaded for the years 1991, 2005 and 2018. Land use and land cover types in the Municipality were identified. They are water, wetlands, grasslands, farmlands, bare lands and built-up areas. This chapter also provided the major changes that occurred among the LULC types identified and also discussed the implications of such changes.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter wraps up the research findings derived from undertaking this project. It answers the research objectives, summarises the findings and delivers conclusions identified in the findings. Again, it gives recommendations on how to deal with issues of land use changes, flooding and erosion.

5.2 Summary

The study examined the land use and land cover types that constitute the landscape of Keta Municipality. There was reliance on remote sensing application through the use of Landsat satellite imageries acquired from the United States Geological Survey (USGS) website at no cost, and their subsequent processing that led to the quantification of the surface area of all the LULC types. The identified LULC were water, wetlands, grasslands, farmlands, bare lands and built-up area. Based on their respective surface area which differed over the years, the study was able to discuss the underlying changes and also was able to provide the main causes for the changes that have occurred. This therefore satisfied the second objective of this study which sought to investigate the changes that occurred among the LULC types in Keta Municipality.

Generally, it was realised that agricultural expansion is on the increase in the study area. This is needed to support the increasing population, but the concern is that improper farming mechanisms could harm the natural environment. One would agree the reduction in wetlands across the study

area is as a result of the increase in agricultural lands. This create major flooding and soil erosion threat. Already, the municipality is known to be battling for these unfortunate occurrences which have a toll on life and properties. The reduction in built-up areas in Keta Municipality in 2018 as identified in this study could be linked to flooding and erosions that continue to befall the municipality.

5.3 Conclusion

The study used remote sensing to determine the land use and land cover types in the Keta Municipality. There have been considerable changes in the land use and land cover from 1991 to 2018. It was established that increase in farmlands continue to be one of the leading causes of land degradation and deforestation in Keta Municipality. The major concern is that Keta Municipality could be faced with devastating flooding and soil erosion should the wetlands in the Municipality reduce. Already due to the land tenure system in place, these protected areas are being encroached upon for various purposes.

5.4 Recommendations

After a thorough and meticulous study and analysis of the problem and its entire ramification as indicated in the preceding chapters, the following recommendations were made.

Regularise the use of land for agricultural development through land registration. This will avoid the conversion of all land cover type into agricultural lands

Protect patches of vegetation that are facing extinction.

Intensify education on best farming practices that are environment-friendly. This will be very beneficial to farmers and livestock owners.

Diversify the occupation of local people by helping them shift from agriculture to other sustainable form of occupation. This will lift the pressure on the land and help in the restoration of the vegetation.

There should be re-enforcement of laws protecting water bodies and wetlands by the Environmental Protection Agency, Water Resources Commission, the Forestry Commission and the District/Municipal Assemblies.

An efficient data collection system and data base on land cover in Ghana, as relevant data needed for in-depth analysis of LULC change is lacking. And once data is unavailable, spatio-temporal analysis becomes very difficult.

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