UNIVERSITY OF EDUCATION, WINNEBA

LANDSCAPE DYNAMICS AND RELATED GEO-HAZARD IN THE GA SOUTH MUNICIPALITY, GHANA

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DECLARATION

STUDENT'S DECLARATION

I, Ezekiel Addison Otoo, declare that this thesis, with the exception of quotation and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE:……………………………………….

DATE:……………………………………………….

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis/dissertation/project as laid down by the University of Education, Winneba.

Yaw Asamoah (PhD)

Signature:………………………………….

Date:……………………………….………

DEDICATION

To my family and friends for their love, devotion and support throughout my entire educational span.

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My first and foremost gratitude goes to my supervisor, Dr Yaw Asamoah for his patience, time, and confidence he had in me. His encouragement and advice kept me going higher. It is my prayer that the Almighty God increases him in strength and in whatever he does and give him long live till the end of the world.

I am also grateful to my family and all my friends for their advice, support, and kindness they showed me throughout this piece of work. I ask for the Lord's blessings and strength for them for their time spent to read through my script and to anybody who made this work a success.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ABBREVIATIONS

DEM	Digital Elevation Model
EPA	Environmental Protection Agency
GGSA	Ghana Geological Survey Authority
GIS	Geographic Information System
GMet	Ghana Meteorological Agency
GSMA	Ga South Municipal Assembly
LULC	Land Use Land Cover
RS	Remote Sensing
UNDP	United Nations Development Program
USGS	United State Geological Survey

ABSTRACT

Given the extent of human activities and the level of excavations taking place, the Mile11 Hills have become a potential geo-hazard zone. This study sought to investigate the extent of landscape change, it causes and possible geological hazards between 1986 and 2018 where explanatory sequential design and the mixed-method research approach was adopted to achieve the study's objectives. The study used spatial cartographic tools (GIS and Remote Sensing) to examine the extent of landscape change. As well, forty participants were purposively sampled and interviewed for the qualitative analysis. The results confirmed the landscape was undergoing both degradational and depositional geomorphic changes. About 56.11% of the landscape underwent degradation while 43.89% underwent deposition. Geomorphic change in the municipality was largely due to anthropogenic change rather than geological changes which were evidenced by the activities of urbanisation, sand mining and quarrying, posing a potential geo-hazard risk to residents in the area. The area was rapidly losing vegetative cover to urbanisation between 2003 and 2018. Possible geological hazards envisaged included earthquake, landscape influenced flooding, mudflow and landslide. It is therefore recommended that drastic measure should be taken to zone and relocate residents from the area. Proper coordination between traditional land owners, EPA, GGSA and GSMA be ensured to enhance proper planning in the municipality. Hazard prone areas should also be zoned and residents relocated to prevent future fatalities.

CHAPTER ONE
INTRODUCTION

1.1 Background of the study

Landscape structure and composition develops continuously in space and time. These developments are attributable to the complex interaction between the natural environment and human activities, resulting in the change of the stability of individual elements in the landscape system and the spatial structure of the landscape (Xiao, Zhao, Sun and Zhang, 1990).

Landscape dynamics also called landscape change, is the process of landscape evolution, tracing the relationship between humankind and the natural environment. It is related to land use land cover change (LULC) (Potter and Lobley, 1996), and views landscapes as holistic entities which reflect the physical and cultural influence (Antrop, 1998). Antrop (2005) defends that landscape could be understood as the way and the aim in which human societies use the land resource, creating patterns that can alter the natural processes, modifying the natural evolution of the landscape.

Landscape dynamics fundamentally focus on the relationship between humans and their interaction in space. Their interaction should focus on the healthy and harmonious balance between humans and the surrounding space or environment.

Numerous studies have shown that there remain only a few landscapes, peripheral in fairly inaccessible locations on the earth that are still in their natural state (Turner, Moss and Skole, 2016). Many landforms and landscapes around the world have undergone tremendous changes since time memorial with peculiar beliefs linked with some in the residential and semi-residential settings within some locations (Otoo, 2017). The factors which cause the change of landscape differ from region to region depending on geomorphic factors such as historical occurrences, climate, precipitation, vegetation, etc. (Farina, 2006).

Recent trends of spatial re-organization coupled with the economic, climatic and environmental crisis have been altering the face of the land worldwide. Landscapes around the world, old or new, prominent or mundane, are increasingly under threat of being irreparably lost (Van der Sluis, 2012). Van der Sluis et al. (2012) affirmed that the Mediterranean landscape was modified by men for centuries which resulted in a more homogeneous habitat, specific habitats and species extinction. They also testified that the existence of conflict between residents within the Mediterranean region especially farmers in the Entedel Parco resulted in the limited local acceptance of parks which contributed to the modification of the landscape. Alternative income and opportunities in other sectors also led to land abandonment as well as lack of maintenance resulted in loss of biodiversity, the decay of terraces and homogeneous landscape.

Pazúrová et al. (2018) reported of a great change in the territorial landscape of Northern Slovakia resulting in the changes in species distribution due to the physical changing condition of the area, increase of settlement and infrastructure, land abandonment and spontaneous reforestation on agricultural fields among others.

In Africa, the United States Geological Service (USGS) reported that Nigeria under the pressures of a rapidly growing population and economy has between 2000 and 2013, experience a diminishing landscape with loss rates increasing to over 2% per year, with its forest cover decreasing by 45% from 1975 to 2013.

Hurni and Wiesman (2010) also noted that Ethiopia is experiencing a drastic landscape change where more than 90% of its highlands which were once forested, currently have a forest cover of less than 4%. The land cover change in Ethiopia is an outcome of natural and socioeconomic factors in time and space (Zewdie and Elmar, 2015). Most importantly, population growth and agricultural as well as urban expansion are the major drivers of landscape change in Ethiopia (Ayele et al., 2016).

Ghana, like most Africa countries, is undergoing a rapidly increasing landscape change which poses a threat to its sustainability (Antwi et al., 2014). Yeboah, Awotwi, Forkuo, and Kumi (2017) emphasised that the rapidly changing nature of Ghana's landscape in most parts of the country could be attributed to rapid urbanisation, poor land tenure system, poor policy framework and lack of political will. They emphasised that most deteriorating landscape in urban centres were as a result of poor land acquisition system and collaboration between environmental institutions and traditional land owners. Also, the lack of political commitment on the parts of government to evacuate or relocate residents in reserved and hazard-prone zoned area has contributed to the changing landscape in Ghana.

In the last four decades, the capital city of Ghana, Accra, has seen a large amount of land cover and land-use change, as a result of lack of proper planning. This has led to intricate serious problems such as potential agricultural failures, soil erosion, deforestation, flooding, and lack of social amenities (Yeboah et al., 2017).

Restrepo et al, (2009), found out that landscape change influenced geo-hazards around the world. They emphasised that landscape including that of the Podocarpus, Cuenca and the Zamora landscapes (Ecuador), Pucara landscape (Peru), Chiapas landscape (Mexico) and Mount Elgon landscape (Mbale, Uganda) have experienced landscape changes which have resulted in several mass wasting related geo-hazards around the world including landslide and mudflow. They further explained that the type of geo-hazard discovered within those areas were dependent on the materials moved and their mode of movement.

Solecka, Raszka and Krajewski (2018), emphasised that the Sierra Leone, Freetown mudflow hazards on August 14th, 2017 which covered, 116,766m^2 of land and killed over 1,141 people, destroying buildings and leaving over 3,000 people homeless could be mainly attributed to the changing nature of the landscape as it was instigated by unfavourable meteorological factors and massive anthropogenic influence on the landscape such as settlement developments, mining, etc. which was on-going at the summit and base of the mountains.

1.2 Problem statement

For centuries now, people have altered the Mile 11 landscape in the Ga South municipality. Evidence from satellite imageries proves that the Mile 11 landscape is undergoing tremendous change due to the influence of denudation processes as well as anthropogenic factors which continues to act on it (Environmental Protection Agency [EPA], 2018).

The Mile 11 catchment in recent times has become a potential geo-hazard zone in the country given the extent of human activities on the hills and the level of excavations. The sprawling nature of Accra and Kasoa and the subsequent influx of people into the Mile 11 catchment have resulted in various human activities including settlement, stone quarrying, and sand mining. This has resulted in terracing of the slope which increases the steepness of the slope and the possibility of landslide and mudflow in the area (EPA, 2018). The use of explosives such as dynamites in quarry site as well as massive sand mining has weakened the base of the mountain and ripped off the beautiful geographical scenery of the ridge. The increasing activities of sand mining and quarrying are influencing tremendous landscape change as well as increasingly jeopardizing the geological stability, structure and function of the landscape (EPA, 2018).

The Ghana Geological Survey Authority has warned that "a major catastrophe awaits the area if the massive development going on in the settlement is not controlled…" (Adu, 2015). In a Graphic interview with the Deputy Director of the Ghana Geological Survey Authority, he stated that "all the debris by the roadside is coming from the surface of the mountain. If it rains continuously and the mountain soaks so much, we can have a major landslide coming down and all those buildings quite close to the mountain will end up in a disaster…" (Adu, 2015). He bemoaned the rate at which the hills is been stripped off its vegetative cover due to the erection of buildings and other human activities, which can cause danger in the future. A section of the hill which provided gravels for the construction of the Kasoa-Mallam road has now become a source of livelihood for some residents in the area who engage in sand mining and quarrying activities further putting their lives and properties in danger. In June 2013, a loose section of the hill collapsed onto the Kasoa-Weija portion of the road creating vehicular traffic which lasted several hours. This situation posed serious threats to the residents in the area as well as their properties and means of livelihood.

The Director of the Inter-sectorial Mining Division of the EPA in an interview with "JoyNews" and "Myjoyonline.com" envisage that there could be an imminent mudflow, rockfall or landslide in the area, if caution and effective strategies are not put in place to relocate, evacuate and earmark the area as a danger zone (JoyNews, 2018). EPA in November 2018 in a Safety Report also raised an alarm of a potential collapse of the Weija ridge. The collapse of the cliff will have disastrous consequences and could cut off the "western corridor" road from Accra as the mud could cover the entire Accra-Kasoa road. A Daily Graphic report on June 8th, 2019 indicated the occurrence of mudflow after a heavy downpour on the Weija-Kasoa road which covered portion of the road about a kilometre away from the Kasoa toll booth, made it extremely difficult for drivers on the stretch(Daily Graphic, 8 June 2019).

According to GhanaWeb news report on November 18th, 2017, the Ghana Institution of Engineers (GhIE) issued a warning that there could be a similar incident of the Sierra Leone mudflow hazard which occurred in August 14th, 2017 which claimed the lives of over one thousand people after three days of continues rainfall. The news report claimed that the conditions which are occurring at the Mile 11 hills are no different from what happened in Sierra Leone (GhanaWeb, 2017). The problem lies with the facts that despite the numerous cautions issues by geological experts and the fact that the process of diastrophism continuously multiplying in the area, which could trigger likely early geological hazard at any given time, the area still remains a preferred location for residential dwelling.

Understanding the spatiotemporal landscape status of an area is an important step to implementing future conservation measures. This requires an in-depth analysis of time series fine-scale Geomorphic Change Detection as a vital tool to trace the trend and the nature of the landscape change (Suleiman, Saidu, Abdulrazaq, Hassan, Abubakar, 2014). Recent advancement in technology, especially spatial technologies such as GIS and remote sensing, offers essential tools for studying the geomorphic change in landscapes at frequent intervals (Vogt-Bahati, 2006). These tools have facilitated the capturing and analysing of spatial and temporal changes in landscapes. Though spatial assessment and quantification of Geomorphic Change are not new in landscape planning and geography, a primary account of these changes in Ghana is missing in academic and research literature (Antwi et al., 2014).

Literature reviewed showed that research in this field mainly focussed on Land Use Land Cover (LULC) change analysis and flood mapping with little or no focus on elevation dynamics and related geo-hazards. It is against this background that this study sought to investigate the dynamics of landscape and related geo-hazards in the study area with focus of elevation change analysis and Land Use Land Cover (LULC) change analysis.

1.3 Purpose of the study

The main purpose of the study was to examine the dynamics of landscape change and related geo-hazard in the Ga South Municipality.

1.4 Research objectives

The objectives of this study was to;

1. Assess the extent of change in the landscape from 1986 to 2018 using Geographic Information Science (GIS) and Remote Sensing techniques.
2. Analyse the factors responsible for the changing nature of the landscape between 1986 and 2018.
3. Evaluate possible geo-hazards which might be related to the changing landscape.
4. Forecast the nature of the landscape by the year 2028.

1.5 Research Questions

1. What is the extent of landscape change between 1986 and 2018?
2. What are the factors responsible for the changing nature of the landscape between 1986 and 2018?
3. What are the possible geo-hazards which might be related to the changing landscape?
4. What will be the nature of the landscape by the year 2028?

1.6 Significance of the study

The results of this study will inform policy makers on policy implementation and strategies to put in place towards combating the challenges posed by the changing nature of the landscape. It will also help in a sustainable town planning within the study area. The study would also serve as a reference material for other researcher in the field of landscape development or other related fields of study. It will as well add up to the existing knowledge in the field of landscape development.

1.7 Justification of the study

Despite the obvious threats of geo-hazards resulting from landscape change in the Mile 11 catchment area, there seem to be little research on this situation. Although some research activities have been carried out in the Weija range catchment, they have largely been centered on human activities and the threats they pose to the Weija dam or the quality of water in the Weija dam in relation to human activities in this ecological area.

Asante, Quarcoopome and Amevenku (2008) of the CSIR: Water Research Institute, in their work titled: "Water quality of the Weija Reservoir after 28years of impoundment", also assesses the impact of human activities on the Weija Dam and the way forward.

Peprah-Asante (2009), a post graduate student of the Kwame Nkrumah University of Science and Technology, in his master's thesis titled " Investigating the Feasibility of instituting Payment for Environmental Services (PES), researched into the relation between people and the environment in the Weija catchment with little work done on the possibility of geo-hazards in the catchment area.

An article published in Daily Graphic in April 8th 2014 and written by Emmanuel Ebo Hawkson captioned “Measures to protect Weija Dam needed” also discussed the strategies adopted at a stakeholder’s workshop to protect the Weija Dam and its water resources (Hawkson, 8 April 2014).

From the above discussions, it can be argued that, even though the Weija catchment has captured the attention of academics and the media considerably regarding human activities and their negative impacts, there still exist a knowledge deficit or gap regarding human activities and their potential inducement of geo-hazards.

This research will therefore help to fill the knowledge gap by bringing to the fore the inherent threats of geo-hazards resulting from various factors, especially human activities. It will also help inform and shape residents knowledge on geo-hazard activities in the area and most importantly inform policy-makers of the various strategies that could be adopted to reduce the incidence of geo-hazards in the study area.

1.8 Scope of study

The study focused on landscape dynamics and related geo-hazards. The study was limited to the Ga South municipality with emphasis on the Mile 11 catchment area.

1.9 Limitations of the study

Given the nature of the study area, time and financial constraints, the researcher had difficulties in using a large sample size. This resulted in the researcher adopting only the Mile 11 catchment for qualitative data collection. Organizing respondents from their place of residence to selected centers for focused group discussion was also a little problematic. This delayed the time estimated to start the discussion but persistent words of encouragement led the researcher to achieving his set goals.

Difficulty in collection of primary data from relevant institutions such as EPA, GSMA, GGSA, GMet etc. posed an initial potential problem to the researcher. This challenge was the result of the seemingly reluctance of staff and officials of this agencies to provide information relevant to the study. This was taken care of by taking a letter from the school authorities that served as evidence that this study was for academic purpose and also meeting the official at their place of convince for the interview session. Thus, the information given was treated with utmost confidentiality.

1.10 Organisation of the study

The research consists of five main chapters. The First Chapter of the study was the introductory aspect of the research work which included; the objective of the study, the background to the study, problem statement, research objective, and questions, significance of the study etc.

The Second Chapter of the research reviewed the relevant literature which was necessary for this research. It reviewed the works of other researchers in a similar field of the study and explained concepts that had a different meaning under the consideration of this research.

Chapter Three of the research details the methodology which was employed in conducting the research and obtaining information.

The Fourth Chapter analysed the findings of the research while the Fifth Chapter of the research highlighted on the summary of findings of the research and gave recommendations as well as areas for further research.

1.11 Definition of terms

- Dynamics: the changing pattern of a phenomena due to internal or external energy or force.
- Landscape: landscape is a combination of physical and biological elements by which human survival is dependent thus basically the earth topographic structure and its surface constituent.
- Geo-Hazards: hazard propelled by geologically related phenomena. This will purposely look at mass wasting related hazards and earthquake/earth tremor.
- Mass wasting: Collective movement of surface materials down-slope as a result of the earths' gravitation.
- Seismicity: Tremors and vibrations that serve as signs and precede earthquakes.

CHAPTER TWO
REVIEW OF RELEVANT LITERATURE

2.1 Introduction

This section of the study is devoted to reviewing of related literature. It was discussed under relevant sub-headings including the meaning of landscape dynamics, global and African changing landscapes, drivers of landscape change, and effects of landscape change around the world. Other aspect of the review considered the concept of mass movement, driving forces of mass movement, mass movement related to landscape change, landscape change and related geo-hazards. In addition to the above, the philosophical underpinning of this research, theoretical perspectives and the conceptual framework were also discussed in this chapter.

2.2 Definition of landscape

The term landscape have different meaning from various fields of studies. In geographical terms landscape may refer to the surface structure of a body. Conservation International (2011), suggest that a landscape be defined as a jurisdictional planning area which incorporates territories of basic regular capital and key production systems. These must be sufficiently vast to catch both production and preservation objectives, yet little enough to make usage possible. According to the ideas of Van der Sluis et al (2012), landscape should consist of a zone or area and should be visualized and perceived by local people and visitors as the results of their actions and culture leading to its current nature and existence. Bertrand (2004) also explained that landscape is the combination of physical, biological, and human elements and hence emphasised that this combination occurs in an instable and complex dynamic fashion. Forman and Godron (1981 and 1986), defined landscape as a heterogeneous and uniform land area made up of cluster of interacting ecosystems that is similar in form throughout the surface. On the contrary, Wiens (2005) contended with the traditional view expounded by Forman and Godron (1981 and and 1986) of landscape being an arena in which humans interact with their environments on a kilometre-wide scale. Instead, he defined landscape regardless of scale as the template on which spatial patterns influence ecological processes.

A landscape as described by Summerfield (1991), makes it quite clear that the landscape of an area includes its visible features including land and landforms which is integrated with natural, cultural as well as man-made features. He laid emphasis that, landscape of different types and forms dependent on the self-image of the people who are inhabitant of the place and how the landscape functions in the given area. This landscape could be classified as physical landscape, cultural landscape, human landscape, coastal landscape etc. The physical landscape according to Summerfield (1991) entails the combination of surface processes such as water, wind, ice, fire, etc. as well as endogenic processes including tectonic uplift and subsidence which sculpts the surface of the earth to present its current looks.

For the purpose of this research landscape will mean an homogenous surface system (a combination of physical and biological elements) within a given territorial area in which humans harmoniously interact with the environment for their survival. This means that the interaction between human and the environment should focus of benefiting the environment as well. The environment should be preserved and its resource extracted judiciously for future generation.

2.3 Definition of landscape dynamics

The rate at which a phenomena changes from time to time in shape, constituent, attitude, performance etc. can be termed as his dynamics. When a force stimulates changes or progress in a landform or landscape through time and space, it is termed as its dynamics.

Changes do not happen in vacuum, they are propelled by other factors. In a geographical contest, dynamics are caused by either internal or external forces or both. Landscape and its topography also undergo changes from time to time, the changes which occurs through time in the topology of landscape is termed as its dynamics.

Potter and Lobley (1996) viewed landscape dynamics as a process of landscape evolution, tracing the relationship between humankind and the natural environment which is related to, but not co-extensive with, land-use and land-cover change. For the purpose of this research the definition of potter and Lobley (1996) will be conformed to.

2.4 Global landscape dynamics

As changes occur in humans, so do changes occur in the earths' geomorphic landscape. A hill located at particular place could turn into a plane after consistent diastrophic agents acting on it. In that same manner a coastal area could also develop rising landscape feature after a tsunami. Leopold (as cited by Schumm, 1979) stated that; in the past geomorphologists concentrated their efforts on the understanding of erosional and depositional evolution of landforms through geologic time. More recently geomorphologists have departed from this approach, when it was realized that it is the details of landscape evolution that require elaboration and explanation if traditional geomorphic problems are to be solved and if geomorphic research is to be of value to those who are managing and attempting to control various components of the landscape (rivers, slopes, flood-plains etc.). Therefore, an understanding of the functioning of geomorphic systems over shorts spans of time is mandatory. When this is attempted it is soon apparent that the extrapolation of measured average rates of erosion and deposition to longer periods of time is misleading, in the sense that they do not reveal the natural complexity of landform development or the variability of existing landforms (Schumm, 1979).

A central question in the Earth Sciences is how rates and styles of landscape evolution have varied over time in response to climate and sea-level change, tectonic and isostatic uplift, and human disturbance. The Quaternary has been a period of major landscape evolution in many glaciated regions of the world, but few data sets of sufficient length are available to assess its significance to the long-term development of landscapes in non-glaciated regions (Nott and Roberts, 1996). Landscape transformations since time immemorial have occurred to meet the needs of the society and its individual units. Today, we can see the effects of many historical changes in landscapes. Over the last few decades, these changes have intensified due to strong socio-economic changes, including changes in agriculture, industry, transport etc. (Antrop, 2004). These transformations are particularly evident in the countries in Central and Eastern Europe, where profound political and socio-economic changes have taken place (Westerberg and Christiansson, 1999).

Recent trends of spatial re-organization (i.e. globalization, the explosion of information or communication technologies, the boom in recreation and travel, etc.), coupled with environmental crisis have been altering the face of the land worldwide. Landscapes around the world, old or new, expensive or ordinary, prominent or mundane, are increasingly under threat of being irreparably lost (Van der Sluis et al., 2012). They affirmed that the Mediterranean landscape was modified by men for centuries which resulted in more homogeneous habitats, specific habitats and species disappearing such as stone wall, grasslands, agriculture field. They also testified that the existence of conflict between local residents within the Mediterranean region especially farmers in the Entedel Parco resulted in the limited local acceptance of parks. Alternative income and opportunities in other sectors lead to land abandonment as well as lack of maintenance resulted in the loss of biodiversity, the decay of terraces and homogeneous landscape.

The National Academies Press [NAP] (2010) testified that the history of landscapes strongly influences their present state and future evolution. In the Earth's northerly regions, the current landscape pattern was largely created by glacial processes that peaked around 18,000 years ago, and present-day debates about agricultural best practices and practical water quality standards require a sophisticated understanding of how the landscape is evolving in response to the de-glaciation. Likewise, coastal erosion is still influenced by uplift and subsidence in response to shifts in ice loading over Holocene time. The fate of global deltas on which hundreds of millions of people depend in turn depends on the delicate interplay of subsidence and sedimentation developed over geologic time. In upland regions, the general importance of tectonic history is obvious; more subtle are the possible effects of variations in uplift rate and climate in influencing the balance of sediment storage and release to downstream river systems. Soils are among the clearest examples of the influence of past time. The soils that support global agriculture represent the integrated effects of tens of thousands of years of biogeochemical processes (NAP, 2010).

NAP (2010) also emphasis that the sedimentary record of Earth's colourful past is a composite of self-recording landscapes. Beyond the drama and fascination of Earth history, the record in landscapes and sediments gives us an archive of natural experiments, performed at full planetary length and time scales, from which to reconstruct planetary dynamics. This deep-time record of landscape evolution also opens an avenue to explore the connections between the Earth's interior and its surface boundary. The morphology and properties of Earth's surface constitute fundamental, directly observable attributes that help constrain the long-term behaviour of the Earth's converting interior and the tectonic plates that gradually move across its surface. Landscapes also provide a chance to test and expand our understanding of the Earth's surface processes by applying them to materials and basic surface conditions (e.g., gravity, atmospheric pressure) very different from the ones with which we are familiar. Practical reasons also exist for studying the record of surface evolution (NAP, 2010).

Nearly every aspect of the present form, composition, and function of earth's surface reflects its evolution over geologic time thus, the surface environment including the services it provides and the hazards it poses cannot be understood outside the context of its history. Second, the subsurface heterogeneity that controls the availability of resources such as water, hydrocarbons, and minerals is in effect a three-dimensional tapestry of fossilized surface dynamics created via crustal subsidence and burial of paleo-landscapes in sedimentary basins. Lastly, the history of surface evolution in landscapes and sedimentary basins provides us with a rich archive from which to extract information on extreme events, natural variability in space and time, and how the surface responds to change. This archive is sometimes the only means we have to observe critical thresholds and other forms of nonlinear response to our modifications of the Planet's surface systems, such as those induced by human activity (NAP, 2010).

2.5 The changing landscape and slope instability

Ige, Oyeleke, Baiyegunhi, Oloniniyi, and Sigabi (2016) talked about slope instabilities as a major danger in Africa where resources worth several millions of dollars are lost every year amid seasons of heavy and light downpours. In West Africa, slope instabilities are caused fundamentally by precipitation. Depending on meteorological and geomorphologic conditions, individual precipitation occasions can trigger little or huge incline failures. Landslide happens as a result of the presence of immersed clay materials on the impermeable layer on soak slopes. Landslide that happened on an incline is enhanced by gravity. The internal and external causes of landslide include vibration, loading and unloading, geometrical change, erosion, weathering, soil water regime change etc. The presence of soil moisture can moreover increase the pore water weight and reduces material stability to cause slope failure. The failure of slope material can also depend partly on the strength of frictional force between the sliding mass and the bedrock (Alexander, 1993; and Matsushi et al., 2006).

Anbalagan and Singh (1996) insisted that, human activities particularly the ones that is related to the construction of buildings, transportation routes, dams and reservoirs, canals and communication systems contributes to the removal of large volume of earth material. These are recognized as having major role in initiating slope failure and increasing the magnitude of damages. Habitation and infrastructure development initiatives in close proximity of streams and rivers, as also over Quaternary deposits, and unplanned debris disposal of excavated rock and debris are observed to aggravate both, landslide and flash floods in Africa.

Landslides, mudflows and other rapid mass movements are conspicuous features of land degradation on steeply sloping terrain. They constitute a threat to property, infrastructure, loss of agricultural land, and often human lives (Westerberg and Christiansson, 1999).

Mass movements have often been regarded entirely as a land degradation problem, and studies have concentrated on finding signs of inappropriate land use. With that approach, natural factors have been overlooked. Basic research on mass movement as a natural geomorphic process in the evolution of land forms is indispensable for understanding the relative importance of natural processes versus human activities. By establishing the geomorphic role of mass movements in landform evolution, benchmark knowledge is obtained, which can be used to establish links between the seemingly short-term effects on human livelihood and the long-term landscape evolution, and thus to comprehend correctly the increasing number of reported mass movements (Westerberg and Christiansson, 1999).

As stated by Ringrose, Vanderpat and Maheson (1997), landscape change progress in Africa may be at present accelerating and also creating widespread environmental issues and thus creating necessities with a chance to be mapped. In Ghana, sand mining, forest degradation and other human activities are aiding the quick evolution of the landscape. For example, around the Owabi waterway in the Ashanti region, investigations by Frimpong (2007) uncovered a serious logging and clearing of the bushes in the catchment area of the river which will give a clear path to sand mining. Thus, with time, the landscape of the area might be altered, primarily through human activities. Another study by Frimpong (2011) on the catchment area of the Owabi River revealed that the rapid landscape change due to human encroachment paved way for built-ups.

An investigation conveyed by Yang (2001) uncovered that anthropogenic activities are the most important factors that influence environmental changes resulting to landscape change. Changes in the LULC are in this way pervasive, progressively rapid, and can have adverse impacts and implications on local, regional and worldwide scales. Ellis (2013) also argued that the causes and effects of landscape changes have been pervasive through pre-history to recent times, mainly as a result of agricultural activities, modern industrialization and the centralization of human populaces inside urban regions. What one can deduce from those submissions will be that changes in landscape have existed with the quest of humans to earn a living. Such changes have occurred through agricultural activities from the time when societies were not as complex and modernised as today. With industrialization to advanced society, there may be a shift of populace from rural areas or provincial areas to urban territories. Thus, the causes and consequences occur around the world at the same time. It can also be argued that though landscape change is facilitated by the needs of the people, the rate and extent will depend on several factors such as the technology of the people and their overall level of social and economic development.

Slope failures are major natural risks happening both globally and locally. They are alluded to as the downslope development of rock debris and soil in reaction to gravitational stresses. Incline failures are for the most part classified concurring to the sort of downslope movement to be specific; falls, slides, and slows. Tragically, incline failure may be a geo-hazard that impacts a wide range of landscapes and also numerous sorts of infrastructures. Slope stability or mass-movement issues happen where sediments and rock or snow moves downslope in reaction to gravity. Potential slope stability issues exist wherever development has taken place at the base of soak inclines.

According to Soeters and Van-Westen (n.d), slope instability processes are the product of local geomorphic, hydrologic, and geologic conditions; the modification of these conditions by geodynamic processes, vegetation, land use practices, and human activities; and the frequency and intensity of precipitation and seismicity. Slope instability is aimed at understanding the causes of an occurred slope failure, or the factors that can potentially trigger a slope movement, resulting in a landslide, as well as at preventing the initiation of such movement, slowing it down or arresting it through mitigation countermeasures. Even though many researchers have written extensively on mass wasting in different context and from different viewpoints, the definition of the term mass wasting is rarely used in many of these research works. Researcher rather use the term "Landslide" as a synonym to mass wasting. According to Coch, (1995), geologists and geomorphologists prefer the term "Mass Movement" as opposed to "Landslide" because the displacements do not always occur on land, but on the seafloor as well and may move by creeping, or falling.

Amponsah (2004) defines mass wasting as "collective movement of surface materials down-slope as a result of earth gravitation". Cruden (1991) defines the term as a movement of a rock, earth or debris down a slope. Varnes (1978) provides a more elaborated position on mass wasting by identifying five types of movement made up of falls, topples, slides, flows and spreads. Goltz (2003) asserts that mass wasting is downslope movement of soil and/or rock under the influence of gravity. Drawing from the various definitions of mass wasting and landslide above, it can be said that the term mass wasting refers to all the processes that involve the earth materials whether in a solid, semi-solid or liquid form downslope under the influence of gravity. Given how wide the term mass wasting and landslide have been used interchangeably, in this study, both terms will be used to refer to movement of materials down a slope even though geologists prefer to use the term mass movement (Coch 1995).

2.6 Driving forces of landscape change around the world

On a global scale, human beings have been the main driving force for the transformation of the Earth's surface for several hundred years (Finlay and Robin, 1997). People have significantly influenced landscape changes.

Landscape change studies in many cases have been limited only to identifying the sizes and types of transformations, ignoring the identification of factors that could have a significant impact on the landscape. Meanwhile, understanding the phenomena that lie behind a specific transformation is crucial in the context of conservations and sustainable landscape management (Antrop, 2006). Understanding the cause and effect relationship is one of the ideas on which the analysis of driving forces of landscape changes is based (Burgi et al., 2004). The knowledge of the causes allows the main driving forces and categories of phenomena that have helped to shape the landscape to be classified. The reason for many changes, especially in suburban areas, is urbanization, and this is causing intensive transformations (Hersperger and Burgi., 2009; Lin et al., 2015). As a result of this, the percentage of urbanized landscapes is increasing at the expense of natural and semi-natural landscapes. Other causes of changes in landscapes include the intensification of agriculture, the succession of forests in abandoned areas, increased demand for service areas, the development of renewable energy sources, and the creation of protected areas (Plieninger and Bieling, 2012).

The land use policy of local authorities is also a frequent driving force of landscape change (Mrozik, Bossy and Zareba, 2012). This often leads to the degradation of historically shaped landscapes that are part of the local cultural heritage which should be protected elements in the land use policy (Solecka et al., 2018).

Pauleit et al. (2010), also presented a review of presentations and synthesis of the discussion during a Symposium on ‘Transformation of rural-urban cultural landscapes in Europe: Integrating approaches from ecological, socio-economic and planning perspectives’ held at the European IALE conference 2009 in Salzburg, Austria. The finding of the review pointed out that the transformation of European landscapes is driven by natural and societal processes in the context of global change. Main drivers are social and demographics changes (aging, shrinking population, migration), economic changes (globalisation), technological change (e.g. development of internet networks), and environmental or climate change.

Finka et al. (2009) characterised landscapes as adoptive social-ecological systems. Whiles Finlay and Robin (1997) points out the challenges for landscape ecology as science to model landscape transformation as a multi-dimensional socio-natural process. These drivers are connected with change of political and social value systems (e.g. end of communism in Eastern Europe) which have marked effects on landscapes. Importantly, they interact with the planning system and political forces in significant ways. Therefore, global trends play out very differently across Europe. While some urban centres continue to grow strongly, particularly in Central Europe a dramatic depopulation occurs in the European periphery, most of all in Eastern Europe. Strong differences can also be observed in single countries. For instance, Dodouras et al. (2009) observed a strong population decline in remote Greek areas where many people leave for the economic centres of Athens and other large cities. Abandonment and neglect of traditional farming landscapes have been a consequence. On the other hand, agriculture has been intensified on more fertile land closer to the urban markets while lack of strong planning and building regulation has led to extensive sprawl around the urban centres.

Similar developments were observed in Slovakia (Finka et al. 2009) where the processes of separation of farming activities occurred. Overall, the arable land, vineyards, and orchards decreased in this country. However, in northern Slovakia, arable land and permanent grassland increased at the expense of pasture land. Loss of farmland was mainly caused by urban development and the afforestation of marginal pastureland. Yet, land that was forested was also far from stable as large forest areas changed into transitional woodlands due to calamities such as wind throws. In total, land cover changed on not less than 4.2% of Slovakia's surface area within a ten-year period between 1990 and 2000 (Otahel and Pazúr, 2009). The main changes occurred in mountain areas and other regions with marginal farming conditions. The political and economic transformations after 1989 and the consequent change of farming policy were identified as key drivers for these landscape transformations.

These processes of landscape change can also be observed in other parts of Europe, for instance, in the Mediterranean countries. It concentrated in particular on the transformation of agricultural landscapes to landscapes dominated by urban forces and the tertiary economy of services like leisure and tourism. Detailed accounts of land use transitions were contributed from Spain and Portugal. In Olzinelles (North-East Spain), a parish of 2286 hector of land size in the municipality of Sant Celoi in the province of Barcelona, forest cover increased between 1851 and 2008 from 76% to 92% at the costs of agricultural land, while the cover of settlements increased to 2.6% (Otero et al. 2009). Expansion of woodlands led to a decline in biodiversity dependent on fields and meadows, such as butterflies. Also, a loss of many cultural and ecological relevant elements such as ponds and stone terraces was observed. While woodlands were protected as natural parks and for leisure, no specific policies existed for the conservation of open landscapes. The study also showed that the loss of farming landscapes has been closely related to land ownership. Traditionally, most of the land has been concentrated in the hands of very few landowners while most of the farmers had only very small land holdings. A greater degree of the large estates was already forested in the 19th century and these became more or less entirely forested and converted into the natural park. Vineyards and dry lands, on the other hand, were mostly in the hands of small landholders. Being economically marginal, these areas are particularly vulnerable to landscape change today. In addition, the sprawl of urban areas into forests, caused by the almost explosive growth of secondary homes since the 1980s, increased the risk of wildfires.

Urban growth in the Mediterranean was also studied in the valley of the Sousa River in north-western Portugal by Pereira and Pedrosa (2009). In their case, the main interest was to understand how urbanisation changed the risk of damage from natural hazards, i.e. floods, mass movements, and wildfires, in the study area. Urbanisation occurred particularly in areas exposed to these hazards. This was the main reason for the increase of risks of damage whereas there was no increase in the intensity of hazards.

Urbanisation limits river canalisation enlargement. Streets, buildings and urban facilities tend to occupy banks and the original flood plain once flat areas are always desirable. Upstream reaches of the main river cannot be canalised without aggravating downstream problems, where the former city area lays. Focus now is forced to move to a systemic approach, where the whole basin must be considered. Distributed actions spread around the basin comply with the drainage net in order to control flow generation. Spatial and temporal aspects must be considered together in a way that the proposed set of solution measures may reorganise flow patterns and minimise floods. Therefore, distributed flow control can be an important alternative, once it acts at the source of the problem. This kind of structural measures is often cheaper than traditional enlargement of drainage channels (Andoh and Declerk, 1999). Considering this brief discussion, it is possible to say that the design of urban drainage measures is a process that must consider local aspects, related to the particular basin and city, making each solution unique. Therefore, the pure replication of successful experiences can most often lead to non-effective solutions and unnecessary expenditure of money.

The reality of developing countries, in general, is much different from the one observed in developed regions. In this way, understanding urban trends in terms of growth and changes of patterns of land use in developing countries is very important in order to support the definition of urban plans and flood control strategies, which should also consider social, cultural and environmental aspects. (Wondimu and Alfskih, 2001)

According to the National Geographic resource library (n.d), erosion is the geological process in which earthen materials are worn away and transported by natural forces such as wind or water. A similar process, weathering, breaks down or dissolves rock, but does not involve movement. Erosion is the opposite of deposition, the geological process in which earthen materials are deposited, or built up, on a landform. Most erosion is performed by liquid water, wind, or ice (usually in the form of a glacier). If the wind is dusty, or water or glacial ice is muddy, erosion is taking place. The brown colour indicates that bits of rock and soil are suspended in the fluid (air or water) and being transported from one place to another. This transported material is called sediment. Gulley erosion is highly influenced by the nature of topography and landscape. A steep sloping landscape will mean a more impacting erosional effect than a gently sloping one. Sometimes, engineers simply install structures to physically prevent soil from being transported. Erosion control also includes physically changing the landscape. Communities often invest in windbreaks and riparian buffers to protect valuable agricultural land. Windbreaks, also called hedgerows or shelterbelts, are lines of trees and shrubs planted to protect cropland from wind erosion. Riparian buffers describe plants such as trees, shrubs, grasses, and sedges that line the banks of a river. Riparian buffers help contain the river in times of increased stream flow and flooding.

The current period of climate change is speeding erosion. The change in climate has been linked to more frequent and severe storms. Storm surges following hurricanes and typhoons can erode kilometres of coastline and coastal habitat. These coastal areas are home to residences, businesses, and economically important industries, such as fisheries. The rise in temperature is also quickly melting glaciers. The slower, more massive form of glacial erosion is being supplanted by the cumulative impact of rill, gully, and valley erosion. In areas downstream from glacial snouts, rapidly melting glaciers are contributing to sea level rise. The rising sea erodes beaches more quickly causing a gradual and permanent change to the landscape. (National Geographic Resource Library, n.d)

A research conducted by Acosta et al, (2015), on the topic "effect of vegetation cover on millennial-scale landscape denudation rates in East Africa" revealed that the mechanisms by which climate and vegetation affect erosion rates over various time scales lie at the heart of understanding landscape response to climate change. Plot-scale field experiments show that increased vegetation cover slows erosion, implying that faster erosion should occur under low to moderate vegetation cover. However, demonstrating this concept over long time scales and across landscapes has proven to be difficult, especially in settings complicated by tectonic forcing and variable slopes. They investigate this problem by measuring cosmogenic derived catchment-mean denudation rates across a range of climate zones and hill slope gradients in the Kenya Rift, and by comparing our results with those published from the Rwenzori Mountains of Uganda. They find that denudation rates from sparsely vegetated parts of the Kenya Rift are up to 0.13 mm per year, while those from humid and more densely vegetated parts of the Kenya Rift flanks and the Rwenzori Mountains reach a maximum of 0.08 mm per year, despite higher median hill slope gradients. While differences in lithology and recent land-use changes likely affect the denudation rates and vegetation cover values in some of our studied catchments, hill slope gradient and vegetation cover appear to explain most of the variation in denudation rates across the study area. Their results supported the idea that changing vegetation cover can contribute to complex erosional responses to climate or land-use change and that vegetation cover can play an important role in determining the steady-state slopes of mountain belts through its stabilizing effects on the land surface.

In all the industrial countries, rivers have suffered from forest clearance in the uplands, farm drainage in the lowlands and water-proofing in urban areas. Forest clearance took place on the hills, in the valleys, and on the plains. This accelerated water runoff. Ploughing and drainage took place in agricultural areas. This accelerated water runoff. River channels were deepened, widened, straightened and fixed. This accelerated water runoff. Large new urban areas were rendered partially impervious, with roofing and paving materials. This accelerated water runoff. The capacity of flood plains to accommodate peak volumes was diminished by building upon them. Accelerated water runoff raised flood peaks. It then became necessary to place urban rivers into underground culverts or concrete canals, or to supplement their capacity with ‘flood relief channels'. The net effect of all the changes was a dramatic increase in peak storm discharge. Embankments had to be built to prevent overtopping by flood water. When these works are viewed together it is clear that they do not constitute a good use of public or private expenditure' (Turner, 1998)

Data from the U.S. Geological Survey show that the top annual floods along some San Antonio's urban creeks and rivers have become more intense. All cities' creeks and the San Antonio River carry levels of E. coli bacteria too high to allow safe swimming. San Antonio River Authority biologists say the cause is human and animal faeces that wash off of impervious surfaces and into waterways when it rains. These problems leave the city, Bexar County, SARA and others grappling with how best to manage flooding and water quality and whether the most effective way is through regulations or voluntary incentives. The options come down to this: Continue to only send storm water runoff downstream using pipes, culverts and similar hard infrastructure, which is the traditional method, or also incorporate (Low-Impact Development,) LID tools. LID includes about 10 landscaping and design features that let more water infiltrate the ground on site. Most involve plants, usually native ones, set in well-drained soil or gravel designed to catch storm runoff. Among them are permeable pavements, bioswales and rain gardens that act as natural filters. They capture the first flush of rainwater, the runoff most likely to carry concentrated pollutants that have built up over dry periods. Such features also can help reduce flooding. Rain falling on pastureland will produce less runoff than rain falling on a new subdivision or strip mall that's covered in-pavement, experts say. LID mimics predevelopment conditions, slowing the storm water as it travels off a site or giving it more time to absorb into the ground. The point is "to go upstream as far as you possibly can and begin to treat water there and begin to capture water there and let the runoff soak into the soil instead of having huge detention facilities that are downstream," said Larry Clark, landscape architect and vice president of Bender Wells Clark Design.

Flooding can change local landscapes and habitats. For example, John Pomeroy, a professor and water researcher at the University of Saskatchewan, explained that the 2013 Alberta floods changed the Rocky Mountains and foothills region, thus altering everything from how the future floods will play out to how animals will build habitats in these regions (Andrew, 2013). In urban areas, flooding can be extremely damaging and costly, as it can negatively impact infrastructure, homes, and businesses. In the natural environment, however, flooding has a more positive impact on the natural environment as flood water provides nourishment to the landscape (Andrew, 2013). Floods, extreme manifestations of precipitation and runoff processes, form an integral part of the environment and actively participate in landscape formation. After the devastating floods in Central Europe in 1997 in 2002, we cannot help but question the extent to which the course and consequences of these floods were influenced by anthropogenic environmental changes. Other important questions include whether and where such floods might repeat, and how to ensure effective flood control. We are likely to see further climatic changes affecting the local area by extreme weather conditions, i.e. a higher incidence of floods (Baena, Guerrero, and Jansky, 2006).

Factors that causes mass movement are the sum total of processes that render a slope vulnerable to failure, causing the slope to become unstable. Research has revealed that many factors are responsible for the occurrence of mass wasting. These numerous factors are classified in different ways. One such classification is based on geological factors and human factors (Guthrie, 2002; Sidle, Pearce, and O'Loughlin, 1985). Another classification is based on preparatory factors and triggering factors (Crozier, 1984).

Despite the various classifications, factors responsible for mass wasting can broadly be put into two classes (natural and human causes). The natural causes encompasses geological issues such as slope steepness; soil type, size, texture, seismic and earthquake activities, water holding capacity of soil, slope angle, and the influence of gravity on the slope (Crozier, 1984). The human factors include building of settlement, farming, mining, quarrying, road and railroad construction, building of dams and reservoirs and slope terracing (Abbott, 2002).

Slope steepness

The height and angle of a slope is a key factor in mass wasting activities on any slope. The gradient of a slope to a large extent determines the stability of materials on the slope and the relationship that exist between the shear stress and shear strength. It also tells how active gravity acts on slope materials and influence their movement downslope (Alexander as cited in Msilimba, 2007). Slope stability is achieved when the shear stress and shear strength are in a state of balance. Slope stability decreases when shear stress increases rendering the slope susceptible to failure and subsequently leading to geo-hazards. Butler (1976) argues that a reduction in shear strength increases gravitational pull on the slope, adding more stress to the soil or rock mass. Slope steepness also influences the friction and cohesive properties of slope materials. Even though friction depends both on the degree of roughness of the surface and the weight of materials, an extremely steep slope tend to reduce the friction and cohesive capacity of slope mass causing slope failure (Matsushi, Httanji and Matsukura, 2006).

Seismicity and other vibration

Seismicity and earthquakes has also been identified as a cause of mass wasting. (Crozier, 1984: McCall, 1992). Alexander (1993) maintain that earthquakes reduce slope stability by increasing the shear stress while decreasing the shear strength of slope materials. They assert that earthquake waves have three principal effects: an increase in shear stress, weaken inter particle bonding which leads to liquefaction and a reduction in inter-granular bonding as a result of sudden shocks. Seismic activities have partly been responsible for many mass wasting activities in East Africa due to the presence of the East African Rift Valley System particularly in Kenya.

The Weija catchment has been identified as an active seismic zone in West Africa with a long history of seismic activities (Ambraseys and Adams, 1986; Amponsah, 2002; 2004). Sykes (1978), avers that these seismic activities as a result of the location of the area in a convergent zone of fault lines, an extension of the Romanche Fracture zone which extends from Brazil to Africa across the equatorial Atlantic region. This makes the Weija catchment a potential zone of seismic related mass wasting.

The inherent properties of soil

Researchers agree that the quality of soil along a given slope contribute significantly to the incidence of slope failure and subsequent mass wasting activities. Such properties as soil texture, particle size, porosity, permeability, and cohesion and clay levels largely determine the ability of a slope to withstand gravitational pull. This is because these properties go into determining the stress and strength of slopes. Sidle, Pearce, and O’Loughlin (1985) assert that the significance of soil stability are those that influence the rate of water movement in soil and the capacity of the soil to hold water.

Even though clay has high water holding capacity due to its fine textured nature, saturated clay soil can lead to rapid slope failure in extreme cases although it takes a long time to get saturated (Sidle et al, 1985).

Kitutu, Muwanga, Poesen and Deckers (2009) observe that most slumps in Western Bududa (Uganda) are as a result of saturated clay soil in the region. Soils that are less cohesive due to weak bonding may change to semi-liquid and in some cases liquid form due to water infiltration. This reduces the resistance of slope materials and also lubricates the plane along which the materials slide (Selby, 1993). In the Weija catchment, debris flow is noticeable during heavy downpour as materials descend from the Hill slope and occupy various portions of the Accra-Cape Coast main road. The drift of these materials could be attributed to weak cohesion in soil particles which makes them easily saturated and washed downslope.

Geologists and geomorphologists believe that left with the natural factors alone, the incidence of mass wasting would be minimal globally. They attribute the high incidence of geo-hazards to human activities that serve both as preparatory as well as triggering factors (Abbott, 2002, Butler, 1976, and McCall, 1992). Such human activities as farming, quarrying of stones, building of settlements, road and railroad construction impact heavily on the stress and strength dynamics of slopes by decreasing the resistance capacity of slope materials and also make the slope angle steeper (Abbott, 2002). Bennett and Doyle (1997) maintain that such human activities as irrigation, clearing of vegetation, cultivation and digging of land reduce slope strength. In the Weija catchment, various degree of human activities are prevalent and include building of settlement on the slope, quarrying and excavation, clearing of the vegetation for various reasons. These expose the land to erosion and other conditions that reduce slope stability in the area.

Removal of vegetation cover

Vegetation is an important mechanism for maintaining slope stability in highland areas. This is because; the roots of plants provide anchorage for the soil increasing shear resistance or strength and reducing stress level. The canopy also protects the land from the direct impact of erosion activities. The destruction of vegetation deprive slopes of all these important influences thereby serving as a preparatory factor to mass wasting. According to Inganga, Ucakuwum and Some (2001), deforestation contributes significantly to the incidence of landslide in most of the East African Highlands. Deforestation has been noted as a serious problem in Malawi (Kasulo as cited in Msilimba, 2007). Crozier (1984) asserts that deforestation in conjunction with other factors increase the rate of landslide. Between 1930 and 1950, the steep slopes north-east of Puerto Rico were cleared for agricultural purpose and this resulted in gullies and landslides (Clark and Wilcock, 2000). Butler (as cited in Msilimba, 2007) explain that the impact of deforestation can be minimized when re-colonization takes place. In many instances the chances of re-colonization is virtually absent since human activities in these areas are permanent on the one hand and the period required for re-colonization is too long and not permissible under current demand for landuse by man for many activities on the other hand.

Slope undercutting

The cutting of slope basement through activities such as stone quarrying, sand mining and excavation has impact heavily on slope resistance. Scharpe (1938) indicates that human induced landslides resulting from road and railroad excavations are more widespread than landslides resulting from natural factors. In East Africa particularly Uganda, this phenomenon is very prevalent, (Msilimba and Holmes, 2005).

Slope undercutting from quarries, mines, road construction, dams and reservoirs deplete the area of vegetation and also weakens the stability of the area. Undercutting also increases the convexity and gradient of the slope rendering it susceptible to slope failure (UNEP, 2014). According to Larsen and Torres-Sanchez (1998) these human activities significantly alter Hill slope stability. Knapen et al. (2006) observe that many landslides in East Africa are triggered by undercutting which increase flow concentration. Quarrying activities also cause vibration in the slope further weakening particle bonding and create lines of weakness which facilitate mass wasting.

Infrastructural development

The erection of structures such as buildings, industrial establishment, and road and railroad construction exert profound weight on slopes decreasing slope resistance. The heavy weight mounted on slopes due to these activities coupled with the cutting of the slope basement increase the stress level of the slope (Abbott, 2002). This situation renders the slope vulnerable to failure as the support at the base is removed. Slopes only establish stability when there is equilibrium between the resistance and the stress forces, and as load is mounted on slope tops, the resistance of the slope is reduced (Abbott, 2002).

2.10 Landscape change and related geo-hazards

Landslides are a major component of natural disasters and directly responsible for loss of many lives, livelihood, property, the natural landscape and the built environment than is perceived. This is because emphasis tends to centre on the triggering factors such as earthquakes and hurricanes (Spiker and Gori, 2000). Lavell (1994) and Wisner (2001) have observed that while the emphasis is often on high magnitude and low frequency events, small and medium scale events which are localized aggregate and account for large scale losses. The impact of landslides occurrence is often underestimated as they occur together with natural or geological hazards or disasters. This creates difficulty in assessing at any level the true effect of landslide hazards as assessment is often merged with other geological hazards such as flooding and earthquakes (Kjekstad and Highland 2009). Petley et al (2005) lament that landslides themselves are regarded as secondary hazards associated with storms and earthquakes. This has resulted in under-reporting of landslide impacts and has consequently led to poor quantification of the effect of landslides.

The infamous 1970 Huascaran landslide disaster which claimed some 20,000 lives is often referred to as an earthquake disaster because the event was triggered by an earthquake. But Schuster and Highland (2001) attribute the destruction and casualties to the high level of velocity in debris flow. The inability to distinctively estimate the effect of mass wasting or landslide hazards given that they mostly occur in association with other geological hazards has made it difficult to establish the true impact of landslide hazards.

Despite the difficulty, considerable records exist on the effects of landslides on lives, property, the natural landscape and the built environment. Kjekstad and Highland (2009) avers that globally, landslide hazards have caused damage worth billions of dollars and several thousands of death and injuries. Popescu and Sasahara (2000) cited in Juventine (2012) have observed that Japan tops the countries which have suffered losses due to landslides with a projected direct and indirect losses of four billion dollars annually. By its nature and flow, landslide hazards results in damage to structures and what is contained in them. This situation often results in destruction of property.

Juventine (2012) maintain that the structural impact of landslide is the destruction of household dwellings. This they claim is more pervasive in low income communities. Kjekstad and Highland (2009) blame the increase in landslide hazards and subsequent increase in death and injuries in the twentieth century on high population growth and settlement in landslide prone areas. They also identify urbanization as a major variable to the vulnerability of communities or population to landslide. Urbanization has resulted in increased land use without regards to planning, vegetation removal and its related human activities. Between 1978 and 2005, a total of 397 fatal landslides were recorded in Nepal with a total of 2179 fatalities with an average of about 78 deaths per year. The Vaiont reservoir slide in North-Eastern Italy culminated in the death of 2,000 people (Petley, Hearn, and Hart, 2005).

Landslides account for more than 100,000 fatalities worldwide (Petley et al., 2005). South Asia in 2005 recorded a major earthquake resulting in a major slope failure causing an estimated 25,000 fatalities (Dunning, Mitchell, Rosser and Petley, 2007). The Wenchuan earthquake in Sichuan, China caused more than 15,000 landslide events killing approximately 20,000 people (Lin, Wang, Wang and Wang, 2015). The 2004 Hurricane Jeanne which triggered a landslide in Haiti led to some 3,000 fatalities (UNEP, 2014) while hurricane Ivan caused a landslide which buried the town of Guinsaugon in Southern Leyte, in the Philippines in 2006 in which 1,126people were killed with 19,000 people displaced (Catane, Cabria, Tomarong, Saturay, Zarco and Pioquinto 2006).

In Africa, the story is not different. Juventine (2012) has observed that between 1933 and 2010 landslides in Bududa have claimed 516 lives with several others sustaining various degrees of injuries. In 2010 alone, landslides in Bududa killed 400 people and rendered thousands homeless. Landslide hazards have also impacted negatively on infrastructure. A landslide which occurred in Nametsi Parish buried a health Centre together with the nurses who were on duty at the health facility (Juventine, 2012). Roads in the area were also blocked and rendered inaccessible. Kitutu et al., (2009) has catalogued major mass wasting/landslide events which have occurred around the globe and the devastations which came with them. They include the 1999 Vargas State landslide which was triggered by torrential rains resulting in flash floods and debris flow which killed tens of thousands of people and destroyed many homes in Venezuela. The June 11, 2007 Chittagong landslide triggered by heavy monsoon rains killed some 128 people and injured 150 others in Bangladesh. A rockslide in a slum settlement in the Manshiyet Nasser neighbourhood in eastern Cairo killed 119 people in September 6, 2008. A landslide in Bududa District in Uganda destroyed three villages killing 365 people with 8,000 people resettled in March, 2010.

Drawing from the above, it is realized that geo-hazards have impacted severely on the lives, property, the natural landscape as well as the built environment and is still at work like any other geological process.

2.7 Approaches to analysing landscape change

Pauleit, Breuste, Qureshi and Sauerwein (2010), reviewed the methods adopted by researchers during the presentations and synthesis of discussions during a Symposium on ‘Transformation of rural-urban cultural landscapes in Europe: Integrating approaches from ecological, socio-economic and planning perspectives' held at the European IALE conference 2009 in Salzburg, Austria. His finding discovered different approaches and methods are used by researchers for analysis of landscape dynamics, transformations, and impact assessment. These approaches and methods include Interpretation of remotely sensed data (satellite imagery and or aerial photography), Historical analysis, Ecological studies analysis, and Policy analysis, Analysis of planning systems, policies and cultures.

Interpretation of remotely sensed data (satellite imagery and or aerial photography) for detailed analysis of landscape change was adopted by Otahel and Pazur (2009) and Kupidera et al, (2009). These researchers implemented in a GIS system, where data can be effectively combined with conventional maps such as topographic maps, soils maps, etc. and statistical data (e.g. census data) to assess the impacts on natural resources from landscape change and analyse risks from natural hazards (Pedreira and Pedrosa, 2009).

While remotely sensed data, when available, offers the possibility for spatial analysis of landscape change over larger areas, it was also clear that understanding of the underlying causes and impacts of landscape change requires other, partly qualitative methods, and studies at more detailed scales.

Historical analysis and the use of old cadastral maps as well as historical statistical data (e.g. records on cultivated crops, farm sizes and land ownership) was used by Otero et al. (2009) in their studies. Ecological studies, e.g. on biodiversity such as the detailed analysis of impacts of land use change on selected species groups in the Olzinelles' study (Otero et al. 2009).

Policy analysis: A comparative study on urbanisation patterns in three municipalities in Switzerland (Gennaio and Hersperger, 2009) provided interesting insights in this respect. It could be shown that different rates of urban expansion were related to the dominance of specific parties in local politics, distribution of resources among the actors (e.g. access to press media, influence of landowners, etc.), new scientific knowledge but also change in public opinion at national level as an external driving force.

Analysis of planning systems, policies and cultures: Kristensen (2009) provided a comparative study on peri-urbanisation in three countries which showed that planning approaches are important determinants of landscape change but, in turn, they are dependent on natural and social determinants, such as the population density, relative abundance of land and role of agriculture influence on shaping planning systems and policies, historically and today. In the Netherlands, for instance, which is densely populated and where therefore land resources are scarce, local plans regulate the entirety of the land, whereas in much less densely populated Sweden they are restricted to urban areas. This is also the case for Denmark, where farming holds a strong position, one of the main reasons why urban growth boundaries are a strong instrument in this country to preserve valuable farmland. Consequently, patterns of urbanisation are different in these three countries.

In yet other studies, other methods were employed for understanding decision-making processes which closely work together with decision makers and stakeholders. These collaborative research methods may hold potential for trans-disciplinary research. In addition, the study conducted by Kristensen (2009), showed the importance of comparative research. Similarly, Pileri et al. (2009) undertook comparative research between cases in Italy and Germany to identify strategies for reducing land consumption. Studies on cross-border initiatives aiming at sustainable development of landscapes may offer a particular opportunity for this type of research as the implementation of similar programmes (e.g. funded by the European Union) can be studied in a similar landscape context but different planning systems.

Geitner and Tusch (2009) presented a methodology for the assessment of soil functions in rural and urban areas in the Alps, resulting in a soil evaluation system and guidelines for planning. Schetke, Haase and Kotter (2012) developed a multi-criteria approach for assessment of the socio-economic impacts of new housing estates in shrinking cities. This was the only presentation in the symposium which approached the phenomenon of shrinking cities whereas all other presentations rather considered urban expansion. However, shrinking cities are already a quite widespread phenomenon and should, therefore, become an important topic of urban landscape ecological research. Processes of shrinkage may even offer an opportunity for an ecological restructuring of cities. However, this requires methodologies to assess the sustainability impacts of different planning concepts such as infill development and urban extensions. To this end, Schetke, Haase and Kotter (2012) operationalised the concepts of 'urban ecosystem services' and 'quality of life' to be integrated into a decision support system. Both assessment studies of Geitner and Tusch (2009) and Schetke, Haase and Kotter (2012) show how assessment can help to bridge between landscape ecology as science and decision making.

2.8 Examples of mass wasting related geo-hazards

According to Varnes (1978), five types of mass wasting activities can be identified based on the nature of the materials and the type of movement. These are flows, topples, slides, falls and spreads. The classification of mass wasting activities helps to reduce the numerous and yet related mass wasting activities into few recognizable but meaningful groups with common attributes to facilitate scientific study (Crozier, 1984 as cited in Msilimba, 2007).

Falls: This type of movement usually involves small quantities of weak weathered materials dropping from steep slopes. They mostly result from undercutting of the slope base and/or face of the slope by activities of waves or river (Selby, 1993). Bryant (as cited in Msilimba, 2007) argues that falls are characterized by turbulent movement and is defined by the energy line.

Topples: Topples are characterized by rotation and sliding that occurs before falls takes place. This type of mass wasting is predominant in sedimentary rocks with thin bedding planes and jointed igneous rocks (Selby, 1993). According to Ludman and Koch (1982), topples are often defined by jointed intersections or fractures, with their basal stability disturbed by erosion.

Slides: Subdivided into various forms such as rock slide, block slide, mudslide and debris slide. Slides are made up of a mass of weathered materials or debris that moves down a slope along a defined surface (Selby, 1993). They come in various sizes and thickness, normally about 10% of their downslope length. Sliding materials maintain permanent contact with the surface or plane along which they slide and could be translational or rotational slide (Alexander, 1993; Smith, 1996).

Slumps: Slumps are identified with materials that are thick, homogenous and cohesive such as clay (Selby, 1993). They occur in slopes that are concave outward and may result from the undercutting of the foot of a slope. They can also result from poor engineering design of cut embankment.

Flows: This type of mass wasting is largely characterized by materials in semi-fluid to fluid form with high viscous properties. Johnson and Rodine (as cited in Msilimba, 2007) assert that in most flow activities, the structure of the materials change into quasi-fluid. It is regarded as the most dangerous type of mass wasting as the debris can travel long distances away from the source with large materials deposition (Corominas, 1996).

Earth Quakes: This is the sudden shake in the earth crust causing cracks and sometimes the collapse of buildings.

2.9 Addressing issues of landscape change and related geo-hazards

The various measures that are employed to curb or reduce the activities of landslide seen as an integral component in the study of landslides identified landslide management strategies as the sustainable action that reduces or eliminates the long term risk to people and property (Msilimba, 2007) . Various scholars classify the management strategies into soft and hard measures. Crozier (1984) as cited in Msilimba (2007) identifies soft measures to include avoidance of zoning and legislation or regulation. They maintain that soft measures offer effective long term hazard reduction. This position is further deepened by Goltz (2003) pointing out that this measure is cost effective and a long term sustainable measure than the hard measure.

Hard measures constitute those that involve the construction of structures to stabilize slopes and to curb the incidence of mass wasting. They include stabilization geometric methods such as stabilization by drainage, plugging and other measures as afforestation and avoidance.

Stabilization by plugging is more appropriate in areas where the bed has developed joints and fissures leading to instability (Msilimba, 2007). Goltz (2003) avers that plugging is used when stabilization by embankment has failed. Stabilization by drainage was noted by Kitutu et al., (2009) as effective for curbing unstable hill slopes from sliding. Stabilization can also be achieved by afforestation. Root density and tensile capability of trees have the capacity to reduce the flow of materials. Sidle et al. (1985) have observed that maximum tensile strength helps to reduce incidence of landslides.

Msilimba (2007) also expressed a similar view by pointing out that the significant reduction in landslides and mudflow in New Zealand and North Island was as a result of the afforestation programs introduced in those countries. Avoidance is also another means by which landslides or mass wasting could be managed. This measure constitutes a permanent solution to a landslide hazard. Measures include realignment away from the slope, relocation of the facility, or moving away from landslide or mass wasting prone areas. This may be achieved by providing economic incentives to people to lure them to safer places or environment and help them to engage in more environmentally friendly activities (Msilimba, 2007). Control measures that limit the activities of people in landslide prone areas have also proven to be a major strategy for landslide management. Ban on cultivation on slopes greater than 15^o and the prevention of vegetation removal reduces both the velocity and quantum of materials that move downslope and its impact at the slope base (Pike, 1968).

Another strategy for landslide management is protection which focuses largely on containment and/or diversion of materials/debris moving downslope. The protection measures may include walls, berms and catchment basins. These measures are very effective and moderate in cost. Monitoring and maintenance are measures which help to determine in advance early warning signs and also a proactive measure to clean out catchment areas. The measures include routine observation and assessment of conditions of slope, weather instrument and signs of seismic vibrations in prone areas. These measures are relatively cost-effective and highly effective in reducing people's vulnerability to landslide risk (Washington State Department of Transportation, 2014).

2.10 Theoretical perspectives

A considerable amount of research has been carried out over the past decade to explain the concepts and develop models and theories that form the basis of landscape development around the world. These models are based on representations of physical processes which include tectonics, volcanicity, denudation etc. which helps in shaping the natural landscape to its present looks. However, there are still major gaps in the understanding of the morphological behaviour of landscapes and how their evolution could directly or indirectly affect the physical environment (Hanson et al., 2003). In this study, some theoretical explanations underpinning issues relating to the development and evolution of landscape and changes that occur within them are discussed.

Davisian cyclic of erosion

The hypothesis of landform development was given by American Geomorphologist William Morris Davis. Davis's hypothesis was the result of a set of speculations and models presented by him amid the 1880s and 1890s. His concept of topographical cycle (or commonly known as cycle of erosion) given a genetic classification and orderly description of landforms. According to Davis, geological cycle could be a period of time amid which an uplifted landmass undergoes its change by the process of land sculpture ending into low featureless plain or peneplain (which Davis called peneplane). He propounded the model of 'complete cycle of river life' in his paper on The Rivers and Valleys of Pennsylvania (1889), and that of 'geographical cycle' (1899) and 'slope evolution'. He, under the concept of 'complete cycle of river life', hypothesized the cycle concept of dynamic development of erosional stream valleys, and through the 'geographical cycle' described the successive development of landforms through time.

He proposed an elevated or to-be-uplifted landscape. He characterized a young stage where river incision is the dominant process shaping the landscape. Amid the youthful stage height contrasts between uplands and valley bottoms increase rapidly. The youthful stage is followed by a develop stage where height differences between valley bottoms and uplands are at their most prominent. Starting within the mature stage slope decline gets to be a more vital phenomenon, and uplands lose height more quickly than rivers incise, effectively reducing relief. In the very latest stage erosion has acted so long that the landscape in spite of unique height is decreased into rolling lowland. This landscape of low relief is called a peneplain and may contain residual heights standing out from the general level. The peneplain can be elevated, beginning a second disintegration cycle.

Lester Charles King theory of slope retreat

L.C. King's theory of landscape development depended on studies of landforms in arid, semi-arid and savanna regions of South Africa. He postulated a set of cyclic models (such as landscape cycle, epigene cycle, pediplanation cycle, hill slope cycle, etc.) and suggested that these are practicable in other parts of the world as well. The reference system of King's model says "there is even development of landscape in varying environmental conditions and there is insignificant influence of climatic changes in the development of fluvially originated landforms.

He stated that inselbergs are created when scarps retreat backwards leaving a vast pediplain in the wake. Initially for scarps to retreat, interfluves (the region separating adjacent valleys) must be present. Lateral erosion by rivers, sea waves, wind or weathering acts along the sides of the valleys and or scarps wearing them backwards leaving a pediment and pediplain behind. As time goes on, the interfluve is reduced to an inselberg called a monadnock (from Mt Monadnock in New Hampshire, USA).

Pointing out that the Davisian model of arid cycle of erosion was inadequate to explain all types of landscapes, King, in the 1940s, propounded a new cyclic model of pediplanation (or pediplanation cycle) to explain the unique landscapes that he observed in the arid, semi-arid and savannah parts of Africa. According to King, the African landscape consisted of three basic elements:

(a) Rock pediments flanking river valleys and having concave slope varying in angle from 1.5° to 7° cut into solid rocks

(b) scarps having steep slopes bounding the uplands and varying in angle from 15° to 30° and experiencing parallel retreat due to back-wasting by weathering and rain-wash

(c) Steep side residual hills known as inselbergs which vary in size and shape. The size of the inselbergs is dependent on the magnitude of erosion and their shape on the nature of underlying structure.

It is worth noting that King's concept of upliftment and crustal stability is similar to the concept of Davis. The cycle of pediplanation is performed by twin processes of scarp retreat and pedimentation. Each cycle begins with rapid rate of upliftment followed by long period of crustal (tectonic) stability. The cycle of pediplanation begins with the uplift of previously formed pediplains and not of any structural unit. The pediplanation cycle passes through the stages of youth, mature and old as in the Davisian cycle of erosion.

However, there are certain differences between the models of King and Davis. Davis's peneplain is formed due to down wasting while King's pediplain is formed due to coalescence and integration of several pediments which are formed due to parallel scarp retreat. Once formed, Davis's peneplain does not experience further growth until it is uplifted. When uplifted, new erosional cycle is initiated and the rivers are rejuvenated.

On the other hand, King's pediplain once formed further grows head-ward. New scarp is initiated at the far end of the previously formed pediplain which is progressively consumed by the retreat of new scarp and thus second pediplain is formed while the former pediplain experiences decrease in its extent. The process continues and a series of intersecting pediplains are formed which extend head-ward. Hence, King's pediplains, so formed, are analogous to Penck's piedmont treppen.

Marie Morisawa theory of tectonic movements and changes

American geomorphologist Marie Morisawa formulated a geomorphic model based on tectonic movements and changes. She analysed the results of goemorphological studies pertaining to erosion and reliefs undertaken by different geomorphologists in different parts of the world and concluded that "there is high rate of erosion on uplifted landmass because potential energy required for erosion increases due to greater height and high potential energy results in high kinetic energy due to increased channel flow velocity which ultimately accelerates erosion". She said that the rate of denudation and basin reliefs were highly positively correlated and 90 per cent of the total differences in erosion rates in different drainage basins were due to average reliefs of the basins. The main premises of Morisawa's tectonic geomorphic model are:

(a) Landforms are the result of either the inequality of force or resistance or both.

(b) The variations in landforms are due to inequality of rates of operation 'of exogenetic processes acting on different geo-materials of the earth's surface and inequality of the rates of endogenetic processes.

(c) Nature tends to attain balance or equilibrium between force (of processes) and resistance of geo-materials. However, this balance is not always maintained since the earth is unstable and dynamic. The isostatic feedback also affects the rates of upliftment and erosion, and deposition and subsidence.

(d) The current landforms are the result of difference of ratios of the actions of endogenetic and exogenetic processes.

(e) When uplifted or newly created, a landmass undergoes rapid transformation of its form through exogenetic (denudational) processes. The rate of transformation is dependent on the nature of force and resistance.

(f) Some morphological features can be explained in terms of plate tectonics.

Theory of J.T. Hack

American geomorphologist J.T. Hack made a serious attempt to fill the conceptual vacuum created by the criticism and rejection of Davisian evolutionary model of geographical cycle and Penck's morphological system. Hack pointed out that multi-level landscape (polycyclic relief) cannot be explained in terms of multiple erosion cycle (Davisian notion), rather these landscapes can be explained in terms of dynamic equilibrium theory.

According to Hack, geomorphic system is an open system and so long as energy remains constant in the geomorphic system, landscape remains in the steady state condition despite the lowering in the landscape by denudational processes. Hack's model envisages time-independent development of landscape. In other words, "the shape of the landforms reflects the balance between the resistance of the underlying materials to erosion and the erosive energy of the active processes". The main assumptions of the ''Hackian model'' of landscape development are:

(a) There is balance between denudational processes and rock resistance.

(b) There is uniform rate of down wasting in all components of landscapes.

(c) Differences and characteristics of form are explicable in terms of spatial relations in which geologic patterns are primary consideration.

(d) The denudational processes which operate at present have been carved out of the earth's surface landscapes.

(e) There is lithologic adjustment to landforms.

2.11 Theoretical framework

This study was built on the ideas and knowledge of the systems view of landscape change (adapted from Dawson, 1983 shown in figure 1.1). This theoretical framework seeks to explore the phenomenon of landscape dynamics using the systems perspective to help define the driving forces of landscape change, and subsequently used the basis of the outcome to anticipate landscape change related geo-hazards which could occur as the nature of the landscape continues to change.

Two major drivers of landscape change were proposed: These are 'primary determinants' and 'secondary determinant' The former summarizes the initial natural processes which initiate and contributes to the changes in the landscape, example volcanic eruption, plate tectonic, earthquake etc. and the latter relates to the aftermaths of the primary processes, that is the other factors which are mainly biological and culture-induced factors which are responsible for further changing of the landscape over time; example, settlement (urbanisation), mining, quarrying, traditional taboos and regulations, etc.

The primary determinants with the influence of natural factors such as climate (flood, storm), volcanic activities, earthquake, faulting, etc. modifies or influence the nature of the landscape either leading to attrition or accretion. These factors would influence natural environmental changes which are not human induced and hence cause changes or dynamics in the landscape as they continue to act on the landscape.

The secondary determinants on the other hand which are caused by human activities such as settlement, mining, quarrying, traditional taboos and regulations, etc. modifies the natural landscape as they continuously act upon the lithosphere. These human activities usually lead to attrition rather than accretion in most instances. Secondary determinants such as traditional rules and taboos mostly help to keep the landscape unchanged over a long period of time. These factors influence the lithosphere and lead to landscape change over time. When the landscape change will further lead to geological hazards.

When landscape changes occur through primary and secondary determinants, it causes either direct or indirect effects on the determinants. In this conceptual framework those direct or indirect effects are labelled "feedback". These feedback effects on the secondary determinants could be in the form of geological hazards such as flood, landslide, rock fall, and mudflow as well as the destruction of roads, navigation problems, etc. which mostly disturb the harmonious living between humans and the landscape. On the primary determinants, this feedback could perpetuate further primary determinants of landscape change (i.e. earthquake, earth tremor etc.). For instance, landscape change leading to rock fall or landslide could instigate the likeliness of earthquake or earth tremors which would have a direct effect on the secondary determinants (mainly humans). Example, landslide can cause the loss of lives or the destruction of properties.

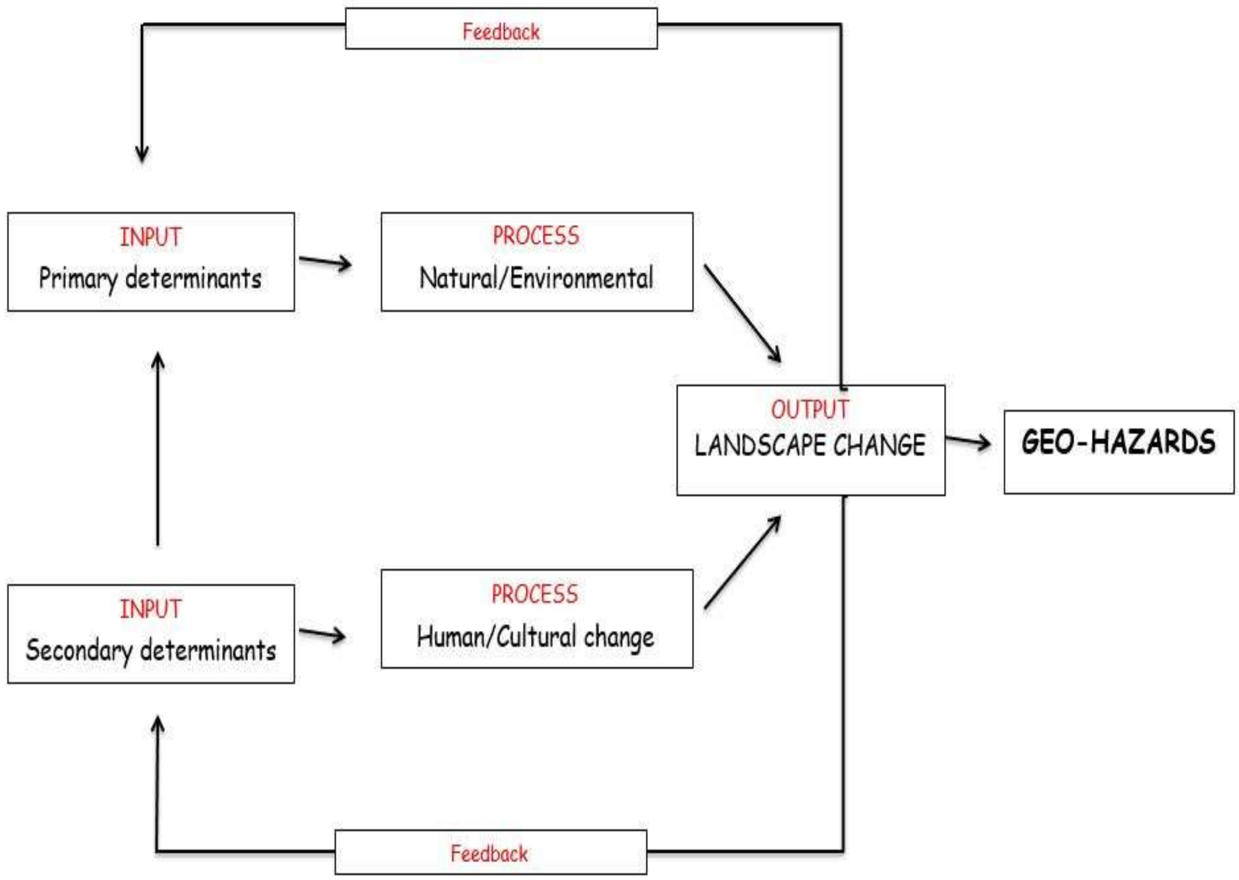


Figure 1.1: Adapted systems theoretical model

Source: Dawson, 1986

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the methodology that was used in the designing of the study. It addresses issues concerned with the research design, the study area, the sampling and data collection that were used as well as the data analysis method.

3.2 Study Area

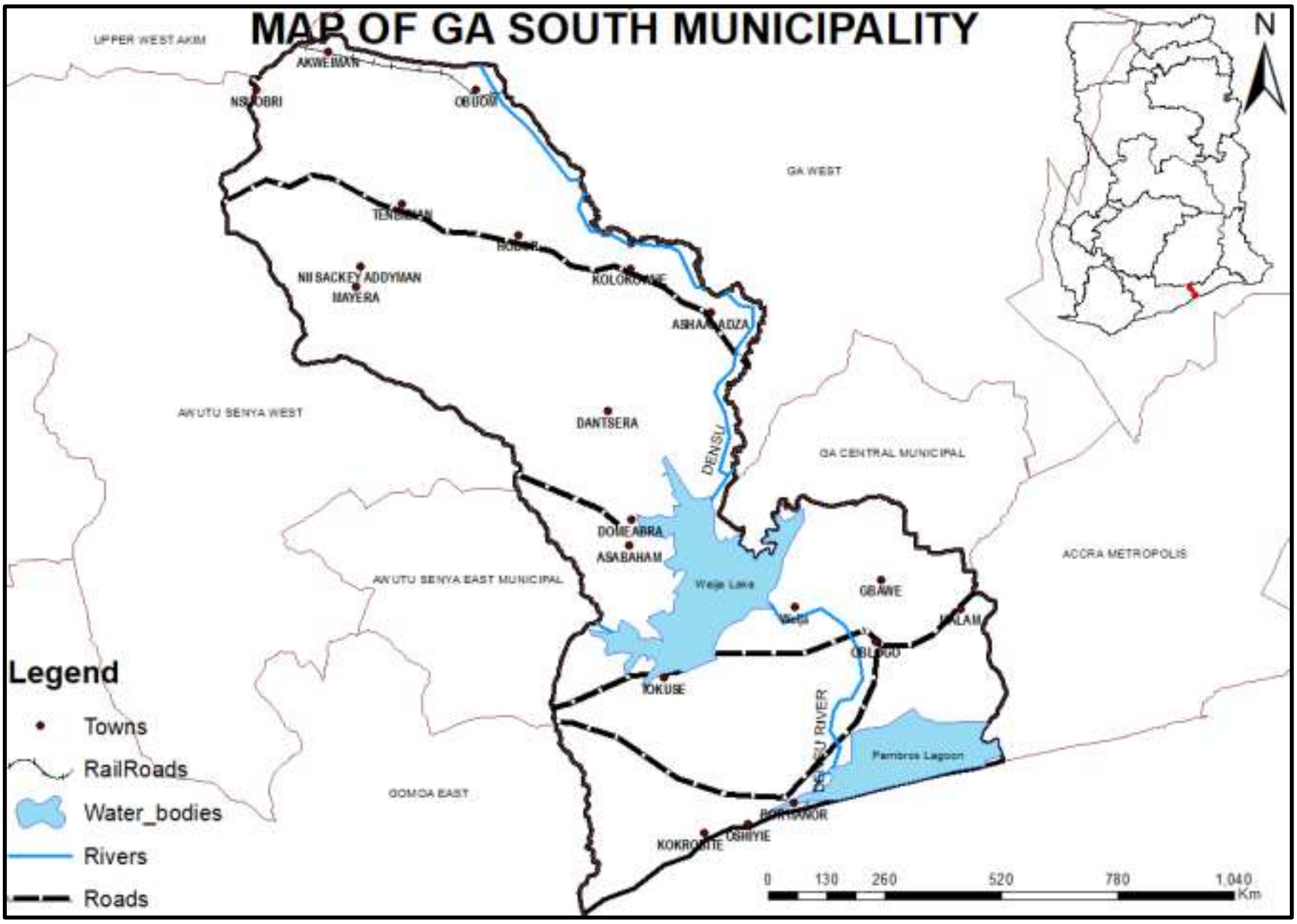


Figure 3.1: Map of Ga South Municipality
Source: Authors construct, 2020 (ArcGIS 10.5)

Location and size

This study is limited to the Ga South Municipal Assembly in the Greater Accra Region. In terms of absolute location, the Ga South Municipal area lies within latitude $5^{o}48$ North, $5^{o}29$ North, longitude 0^{o} 8 West and 0^{o} 30 West. Relatively, the Municipality is bounded to the South-East by the Accra Metropolitan area, to the North-East by Ga West Municipality, to the East by Ga Central, to the North by Upper West Akim, to the west by Awutu Senya West and Awutu Senya East, to the South-West by Gomoa East and to the South by the Gulf of Guinea. The Municipality occupies a land area of approximately 342 km^2 made up of about 362 communities. Specifically, the study area lies between Kasoa Toll booth and Weija junction along the Cape Coast-Accra highway opposite the Weija reservoir towards Accra. For the purpose of this research, the study area would be called the Mile 11 hills or Mile 11 range.

Geology and soil

The land area of the Ga South Municipality is underlain by shallow rocky soil with extensive steep slopes of the Weija-Mile 11 hills. It is composed of basic gneiss inselbergs. The area is underlain by the Accraian, Togo and Dahomeyan formation (McCall, 1992) cited in (Amponsah, 2004). This formation consists of Sandstone and shale with series of folds and faults. These formations are overlain by poorly consolidated to unconsolidated sediments of the quaternary age. The sediments include lateritic soil, gravels, clay and lacustrine sediments. Soils on the Mile 11 range are pale and sandy with quartzite occurring on the surface. Sandstone and limestone also occur in the area.

Vegetation and climate

The entire Municipality lies in the coastal savannah belt with secondary forest occurring in the interior region which receives high rainfall within the year. The area has a bi-modal rainfall pattern with mean annual rainfall ranging between 790mm in the coastal belt and about 1270mm in the extreme north. The annual mean temperature is between 25^{o}C in August and 28^{o}C in February. The hottest periods occur between February and March and have a relative humidity of about 75%.

Demographic characteristics of study area

According to the Ghana Statistical Service the projected total population of the Ga South Municipal area by 2020 would be about 358,893 with an annual growth rate of 4.5%, and an intercensal growth rate of 4.1%. Out of this number, males constitute 49% while the females represents 51%. It has a population density of 14.10 person per hectare. According to the GSMA (n.d) the economy of the area is gradually shifting from agriculture to service and commerce. About 57% of the economically active population in the area are engaged in service and sale related occupations such as teaching, shop attendants, nursing, sales executive etc.

3.3 Research Design

Research design is a comprehensive plan for data collection in an empirical research project. It is a “blueprint” for empirical research aimed at answering specific research questions or testing specific hypotheses (Bhattacherjee, 2012). The research design which was adopted for this study was the explanation–sequential case study design. Explanatory research is conducted to identify the extent of cause-and-effect relationship between phenomenons whiles sequential research provides a study in different phrase where the first phase directs the basis for the second phase. A case study design is a comprehensive enquiry into part of a subject with similar attributes to the entire subject under study to obtain an understanding of the whole subject. This design was adopted because preliminary literature reveals that there are few studies done in this field of research hence the need to explore further. The design also allowed the researcher to probe systematically the problem and provide in-depth information about the changing nature of the landscape from the quantitative view (using Remote Sensing and GIS) and then use the basis of the quantitative framework to build on the qualitative aspect of the study with the sense of integrating the data from the two separate strands of data. The research design helped to increase a researcher's understanding of the subject thus providing a better understanding of the research problems than the use of either one method alone.

3.4 Target population

The targeted population was the residents of the Mile 11 Hills and its surrounding environs who were more than eighteen (18) years of age and had lived in the community for at least 10 years. The age target was used to select residents who were older enough to provide historical information relevant enough to the study. The basis of the 10 years duration of stay also gave access to residents who have lived in the area longer enough to provide valuable information from their own experience and observation as well as eliminated people who were visitors and did not have enough knowledge about the phenomenon under investigation.

The study also targeted traditional authorities as well as officials from the Environmental Protection Agency (EPA), the Ga South Municipal Assembly (GSMA), Ghana Meteorological Agency and the Ghana Geological Survey Authority (GGSA). Traditional Authorities were justified respondents in this study because they are the trustees of lands in the Municipality and hence are heavily involved in the protection and sale of stool lands as well as development in the area. The Ga South Municipal Assembly is also the governments' representative of the area who is in charge of implementing government policies in the local area. They perform environmental and engineering duties such as issuing building permits, community planning and infrastructural developments such as roads, hospital, schools etc. which relates to landscape change. Ghana Meteorological Agency gave access to information relating to the rainfall pattern in the area, amount of rainfall received etc. and how they influence landscape change and relates to geological hazards. The GGSA and EPA were relied on because of how their works relates to geologic analysis and survey (crustal structure analysis), environmental protections and safety, public education and public safety respectively for information on how their offices view landscape change, their causes and effects as well as their relation to geological hazards in the area.

3.5 Sampling size

The sample size for this study was thirty-two 32 participants from the Mile 11 community. This number was due to the utilization of the qualitative approach in sampling respondents for the study. Interaction with respondents was persistent till saturation was realized. Many authorities have suggested different sample size range for qualitative research. Morse (1994) suggested approximately 30-50 participants while Creswell (1998) suggested 20-30 participants, hence the realized sample size of thirty-two is deemed appropriate for a study of this nature.

3.6 Sampling technique

The purposive sampling technique was used to select suitable respondents for the study. A purposive sample is a non-probability sample where respondents are selected based on characteristics of a population and the objective of the study. Purposive sampling is also known as judgmental, selective, or subjective sampling. Purposive sampling was very useful in this study because there was the need to reach the targeted sample quickly and the sample for proportionality was not the main concern.

The expert based purposive sampling was used to select respondents rooted in the knowledge and expertise of landscape analysis and disaster. This sampling method allowed the acquisition of expert views and opinions on the study and also informed the research about technical issues related to the problem under discussion. A criterion based purposive sampling was also used to select respondents who fell within the given criteria for the study who shared a common set of characteristics specified by age and where put into six focussed groups depending on their residential location and gender. This technique made it possible to eliminate residents whom the researcher perceived might not have adequate knowledge of the study. Purposive sampling enabled researcher to extract a lot of information out of the data collected. This allowed the researcher to describe the major impact of the findings on the population. This method was extremely time and cost effective as well as interest and expert based as compared to other sampling methods.

Twenty-four (24) participants who were residents of the communities and fell within the selection criteria were selected with the criterion based purposive sampling technique while the expert based purposive sampling technique was used to select eight (8) persons including an official each from EPA and the Ghana Meteorological Agency (GMet), the Municipal Chief Executive and a municipal engineer, the assembly member of the area, two traditional authorities (elders) and an official from the Ghana Geological Survey Authority. This enabled the researcher to select participants who substantially contributed knowledge to the topic. The purposive sampling technique allowed the researcher to select respondents who were very relevant to the subject under study in relation to the given criteria, their position in the community or their professional occupation.

3.7 Data collection instrument

Digital data set of elevation (through a 10 m Digital Elevation Model [DEM]) for the years 1986, 2003 and 2018 was derived from the United States Geological Survey (USGS) official website (www.earthexplorer.usgs.gov) and Google earth. The study also used a structured interview guide to collect data from respondents (residents and experts), which helped the researcher to acquire in-depth and detailed information of the participants' personal thoughts, perceptions, opinions.

3.8 Pre-test

The pre-test was done by testing remote sensing and GIS software to ascertain their efficiency. Similar data sets of elevation and satellite images were run with the software to determine the processing extent and efficiency of both the Laptop and software's used. A reconnaissance survey was conducted by the researcher to familiarize himself with the terrain and also observed the extent to which geological processes is taken place in the area from both human and natural causes. This phase was timed and took place on two different occasions. The first observation was in July, 2019 during the rainy season, while the second observation was in January, 2020 during the dry season.

3.9 Data collection Procedure

Qualitative data collection procedure

The data collection exercise was carried out in two phases. The first phase was the conducting of an in-depth interview to professional from various agencies and departments. Experts discussion through interview was held with officials from EPA, GMet, GSMA, GGSA and traditional authorities at their various place of convenience.

The questions from the interview were based on the research objectives. The second phrase was a focussed group discussion with selected residents of the area. Data was collected from selected residents using the focused group discussion technique. Six focuss groups were created for discussion in three diferent areas (two group in each area) depending on the location and gender of respondents. Discussions were held for both gender groups in each area. The first group was located around Finny Hospital which consisted of four males and four females in separate discussions, the second group was located at the taxi rank and consisted of three males and five females while the third group was also made up of three males and five females located at Last Stop area. Still photographs of observed phenomena on the field were also taken as part of the data collected.

Quantitative data collection procedure

Available data and software

The research is primarily a historical pattern change analysis which used multi-temporal and multi-sensor satellite imagery. Landsat images for the following dates 1986, 2003 and 2018 with different sensor and pixel resolution were used. An equal interval of data was not achieved due to the unavailability of clear satellite image of the area. The researcher extended the study period to 2018 due to unclear satellite image for the study area in the year 2016. The satellite images selected and used were within the dry season that is between the months of November and February. This was because of the difficulty in obtaining cloud free images in the rainy season.

Table 3.1: Satellite data and characteristics

Satellite/sensor	Path	Row	Acquisition date	Season
Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) Landsat-8	193	56	12-JAN-2018	Dry season

Enhanced Thematic Mapper Plus (ETM1) Landsat-7	193	56	12-FEB-2003	Dry season
Thematic Mapper (TM) Landsat 4-5	193	56	22-DEC-1986	Dry season

Landsat images of the study area were downloaded from the United States Geological Survey (USGS) website (http://earthexplorer.usgs.gov/). Selection was done from the available free satellite images to exclude those that had more than 10% cloud covered or stripped. Three Landsat scenes spanning a period of 32 years were selected for the study but unfortunately an equal period interval was not achieved due to the unavailability of clear satellite image. Also Higher spatially resolved images such as the Syste`me Pour l'Observation de la Terre (SPOT), Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER), QuickBird, and IKONOS which have the potential of improving classification of land-cover attributes (Lillesand et al. 2004) could not be used because of their relatively higher cost.

The following software was used at various stages; ERDAS® IMAGINE 13 for image analysis, Google Earth Explorer Pro for ground truthing, ArcGIS® 10.5 for G.I.S. analysis and map making. Charts, graphs and statistical analysis were done using Microsoft® Excel 2013.

Image processing and Accuracy assessment

Image Pre-processing

Pre-processing operations were carried out to correct for radiometric distortion of the images because of curvature, rotation of the earth, atmospheric and sensor effects. The Haze reduction module in ERDAS Imagine was used to correct haze on 1986 image since portions of the image had some amount of haze which could potentially affect the classification. Haze was not corrected on the 2003 and 2018 images since portions of the image with haze on them were few and hence could not affect the classification. Noise reduction module was also used to process the three images to give a better and an enhanced image for classification.

Image stacking

Reflective bands 2, 3, 4, 5, 6 and 7 of each image scene were stacked and used in an image-to-image geometric projection were all the six reflective bands were combined into a single image using the Layer Stack Tool in ERDAS Imagine Software and then rectified.

Image sub setting / Extraction of Subset (Study Area)

The images used for the study covered all parts of Ghana. An area of interest (AOI) tool in ERDAS Imagine was used to consider only the study area (Ga South Municipal) and subsets for all the three images (1986, 2003 and 2018) at different sessions. This helped to extract the Area of Interest from the rest of the outlined map.

Image classification

An unsupervised classification was first done using the classification algorithm, Iterative Self-Organising Data Analysis Technique (ISODATA) with a maximum iteration of 10, classified into 200 different classes with a signature for detailed classification of phenomenon in the study area. The unsupervised classified data was hence grouped into various categories with the help of Google Earth Pro for ground truthing, where the reflected images were given specific colours. Using the supervised maximum likelihood algorithm the unsupervised image was re-classification. The utility of the algorithm is that it takes the variability of the classes into account by using the covariance matrix and allowing land covers to be specified more explicitly by allocating to each image pixel, on basis of the spectral properties of the image, the class with which it has the highest probability of membership.

In the case of this study, the maximum likelihood algorithm was most suitable for minimizing classification error. Training sets were defined of each land-cover class from which spectral signatures were generated for image classification. The training polygons were digitized on screen based on terrain knowledge acquired with the assistance of Google Earth Pro, were Google Earth Pro images were back dated to suit the image being classified. The pixels in the polygons that were selected as representative of each class were plotted in spectral space. Places with similar spectral properties were combined to give one image class with the assistance of a suitable classification scheme. The probabilities of the individual cover classes were adjusted and used to reclassify images until the outputs reflected the expected class frequencies obtained through. After the image classification stage, the accuracy of the supervised image classification was assessed. Forty Random Control Points were created for the ground trothing and expressing classification accuracy for the classified images. The outputs were digital images of which each pixel was assigned to one of the below-defined classes.

Table 3.2 : classification scheme used to assign pixels to land-cover classes
Source: FAO, 2000

Land cover	**Explanation**
Builth up	Dense built-up areas with little or no vegetation and Built-up areas at the periphery of urban core with or without patchy vegetation with paved or unpaved roads
Bare Area	Areas with no vegetation cover and exposed rocks as well as soil surfaces e.g. Exposed Rock surfaces, tied and untied roads and bare areas without houses.
Vegetation	Fallow vegetation where the natural vegetation is predominantly grasses, grass-like plants, shrubs, trees.

Water body	All water bodies including salt pan, lagoons, lakes, streams, dams, ponds, rivers, Sea etc.

Elevation change method

Creation of DEM

Due to the unavailability of DEM data for the specified years at the USGS official website it became necessary for the creation of DEM data sets with the help of Google Earth Pro. Due to the unavailability of Google Earth image for 2018, point feature for 2016 was used instead of 2018. Point features or point coordinates were randomly collected to cover the study area for the specified years (1986 and 2016). The coordinates was saved as a path in a KML format. The KML file containing the point features for the various years was uploaded into the TCX converted and the elevation data updated (giving the elevation of every point feature collected). The output was then saved into a CSV file extension. The CSV file was then opened and unnecessary fields deleted leaving the field for longitude, latitude and altitude data (this was done for all the specified years).

Conversion of elevation data

Since the elevation data was originally in meter which might create the potential of no significant change being detected due to the high metric unit of metres, it became necessary to convert the elevation values from metre to feet. The formula of 1 metre being equal to 3.28084 foot (approximated to 1m = 3.281ft.).

ArcGIS Operation

The CSV file (containing the point features as well as elevation values of those points in feet) was imported into Arc Map 10.5 and the display XY data set to X=longitude, Y=Latitude and Z= Altitude. The file was then exported into a shape and the coordinate system set as well as projected accordantly. The file was then converted into ‘‘TIN’’ using the Spatial Analysis Tool in the ArcMap tool box. Other ArcGIS operations were performed to acquire answers to the research objectives. Overlay analysis for 1986 and 2016 was done using the Raster Calculator function in the ArcGIS Tool box.

3.10 Data presentation and analyses

After the researcher had gathered the data that was relevant for the empirical study, it was important to analyse and interpret the data. Data analysis was useful to this study because it enabled the researcher to analyse and give meaning to the data that were gathered from the study. It was within the purview of the researcher's ability to analyse and interpret data that the researcher's research problem is solved.

The qualitative data was analysed using the interpretative technique to analyse observation and interviewed information obtain while quantitative data was analysed using spatial analysis tools including ArcGIS 10.5, ERDAS IMAGINE 2013, and Google Earth Pro. These tools were appropriate because they enabled the acquisition of captured satellite images and provided the basis for analysis of spatial patterns in the landscape change which has occurred within the studied time series, their statistical rates of change and hence provided a framework for analytical projection of the nature of the landscape by the year 2028.

Statistical diagrams such as bar graphs, pie chart, histogram etc. were used to represent the data. Cartographic images, maps and pictures were also used to present and analyse the data.

3.11 Ethical consideration

In this study, ethical issues were highly considered. Institutional consent was sought with a letter from the Department of Geography Education, University of

Education, Winneba (UEW). Consent was also sought from the chief and elders of the community as well as family heads to enable the researcher interact with the residents and family members. The participants were given clear explanations on the objectives and details of the study as well as its benefits. Those who agreed to take part in the study were asked to give acknowledgment by willingly devoting to participate in the study. They were also made aware that, notwithstanding their consent given, they were free to pull out from the study at any point in time they felt they did not want to continue.

This research was self-sponsored and therefore came with no form of compensation for participants of the research. This ensured that the responses from the participants were not based on the account of the hope of remuneration. The principal investigator also had no conflict of interest with regards to the study.

CHAPTER FOUR
ANALYSIS AND DISCUSSION OF RESULTS

4.1 Introduction

This chapter presents the analysis and discussion of both quantitative and qualitative data gathered by the researcher. The analysis and discussion is to find answers to research questions raised as well as achieving the objectives of the study through valid interpretations. This ultimately addresses the arduous task of the study in two folds; they are the quantitative analysis which used cartographic and spatial analysis tools including GIS, Remote Sensing, and satellite images, and the qualitative analysis which involved thematic analysis of the individual interviews which were conducted under various themes and headings drawn from the objectives to establish patterns of meaning and interpretation in the data.

4.2 Demographics of respondents

The research investigated the demographic characteristics of respondents selected for the qualitative aspect of the study. Gender, age and duration of stay in their respective residents were analysed. Details of those demographics are discussed below.

Gender of Respondent

From the sample size of 32 respondents, the distribution of females and males in the study area was 18 and 14 respectively representing 56.25% of females and 43.75% of males. This information is represented in Table 4.1.

Age of Respondents

In terms of age distribution, the researcher strategically chose the age gap of 18 years and above with the aim of targeting the adult population. This helped the researcher seek the views of those who have much historical experience within the community and those with relatively older experience for a holistic analysis. This data was group between residents and expert professional. From the data analysis fifteen resident respondents were between 18-30 years, ten resident respondents were between 31-40 years, three resident respondents were between 41-50 years, four resident respondents were between 51-60 years and two resident respondents were above sixty years. Data collected from expert professional indicates that one person was between 18- 30 years, four between 31-40 years and two persons between 41-50 years. Details of this analysis are shown in Table 4.1.

Duration of Stay of Respondents

From Table 4.1, it was realized that majority (12) of the residents have lived in the community between 10 to 15 years representing 50 %, followed by those six residents who have stayed in the area between 16 to 20 year with a representation of 25% while 2 and 4 residents respectively have stayed in the area between 21-25 and 25-30 years representing 17% and 8% respectively.

Table 4.1: Demographics of Respondents

	Frequency		*Percentage*	
Gender				
Male	14		56.25	
Female	18		43.75	
Total	32		100	
Age				
	Residents	Experts	Residents	Experts
18-30	15	1	62.5	12.5
31-40	10	5	41.67	62.5
41-50	3	2	12.5	25
51-60	4	0	16.67	0
60 and above	2	0	8.33	0
Total	24	8	100	

Duration of Stay		
10-15 years	12	50
16-20 years	6	25
21-25 years	2	17
26-30 years	4	8
Total	24	100

4.3 Dynamics of landscape change

This portion of the data analysis was done quantitavely with the help of spatial analysis and cartographic tools embedded in the ERDAS IMAGINE 2013, GOOGLE Earth Pro, and ERIS ArcGIS's ArcMap 10.5 softwares. The dynamics in the landscape was viewed from two main points. They are Digital Surface Model (DSM) and Digital Terrain Model (DTM). The DSM and DTM combines to form the Digital Elevation Model (DEM). The DSM analysis changes in surface features such as buildings, roads, vegetation etc. while DTM analysis geomorphic features mainly landform or geologic structure. In this study the DTM was done with the help of elevation data manipulated through ESRI Arc Map 10.5 while the DSM was done through Land Use Land Cover (LULC) change analysis with the help of ERDAS IMAGINE 2013. This two modelling techniques helped to determine the changes that has occurred in the geological structure of the landscape given evidence with its implication on the surface landscape.

4.3.1 Geomorphic interpretation of elevation change detection

The change in elevation realised from statistically information gathered in the municipality proves that the municipality's landscape is undergoing a rapid geomorphic change which includes both degradation (denudation) and aggradation (deposition).

Data evidence from statistically classified elevations shows that 23.1 hectares of land were below sea level that is 0 feet in the year 1986. This number decreased to 21.6

hectares in 2016, which implies that 1.5 hectares of land has further undergone denudation to fall below sea level. In 1986, 14141.4 hectares of land had an elevation between 0-100 feet but decreased by 27 hectares leaving 14114.4 hectares of land between 0-100 feet. Elevation between 100-200 feet also witnessed a decrease of 13.3 hectares between 1986 and 2016 from 10503.8 hectares to 10490.5 hectares. By 2016, elevations between 200- 300 feet had increased tremendously by 63 hectares leaving the current size at 5835.1 hectares compared to its size of 5772.1 hectares in 1986. The year 2016 saw an increase in elevations between 300-400 feet from 2667.8 hectares in 1986 to 2669.8 hectares in 2016, indicating an increase of 1.9 hectares of land. Elevations between 400-500 feet had decreased by 3.0 hectares by 2016 leaving the current size at 989.8 hectares from the initial 992.8 hectares in 1986. By 2016, there had been a drastic decrease of 20.4 hectares between elevations classified 500-600 feet leaving it current size at 236.2 hectares from its initial size of 256.6 hectares in 1986. The year 1986 had 64.5 hectares of land above

600 feet, this increase to 64.9 in 2016 implying an aggradation of 0.4 hectares.

Table 4.2: Elevation classification and size from 1986 and 2016

Elevation Classification and Size for 1986 and 2016			
Elevation in feet	1986 (hectares)	2016 (hectares)	Change (hectares)
Below 0	23.1	21.6	-1.5
0-100	14141.4	14114.4	-27
100-200	10503.8	10490.5	-13.3
200-300	5772.1	5835.1	63.0
300-400	2667.8	2669.7	1.9
400-500	992.8	989.8	-3.0
500-600	256.6	236.2	-20.4
600 and above	64.5	64.9	0.4
Total	34422.2	34422.2	

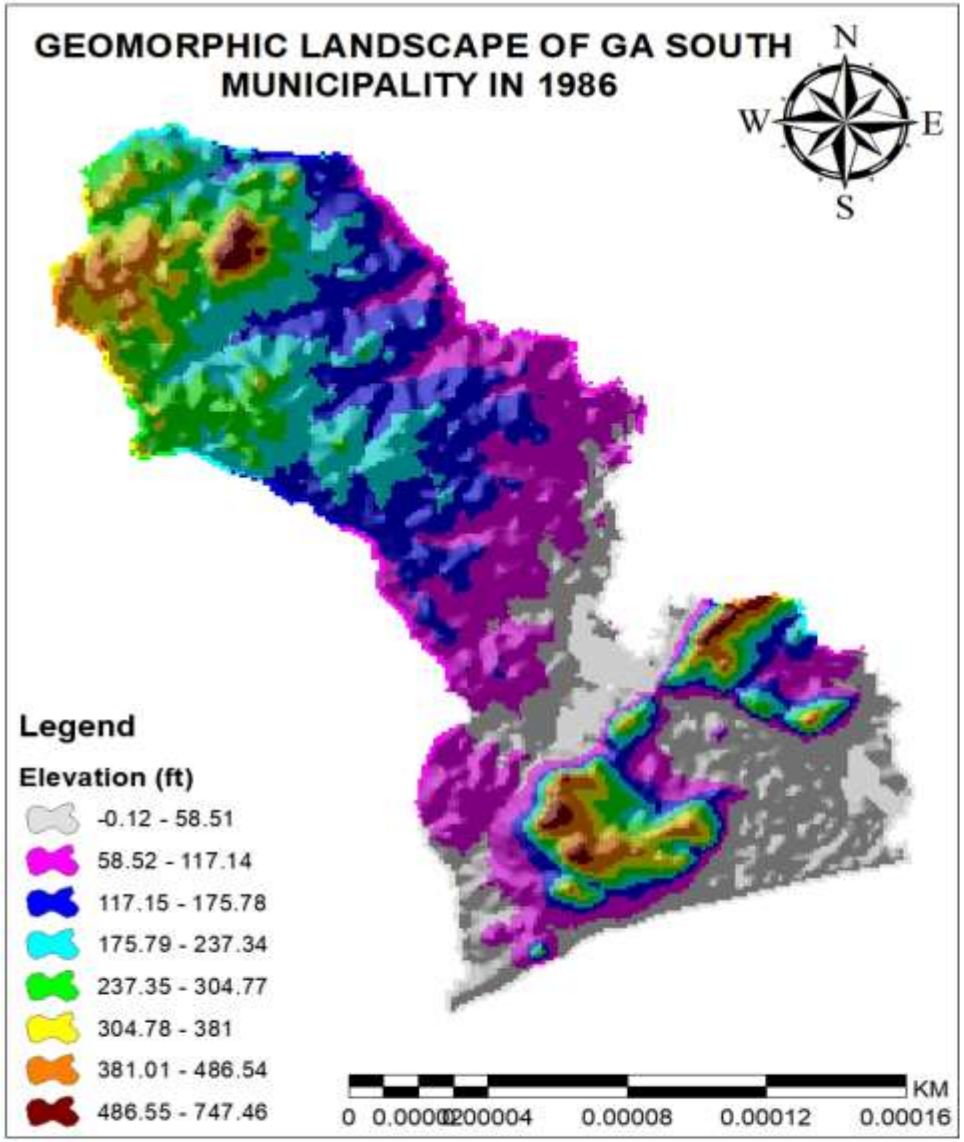


Figure 4.1: Geomorphic landscape of Ga South Municipality in 1986
Source: *ArcGIS 10.5*

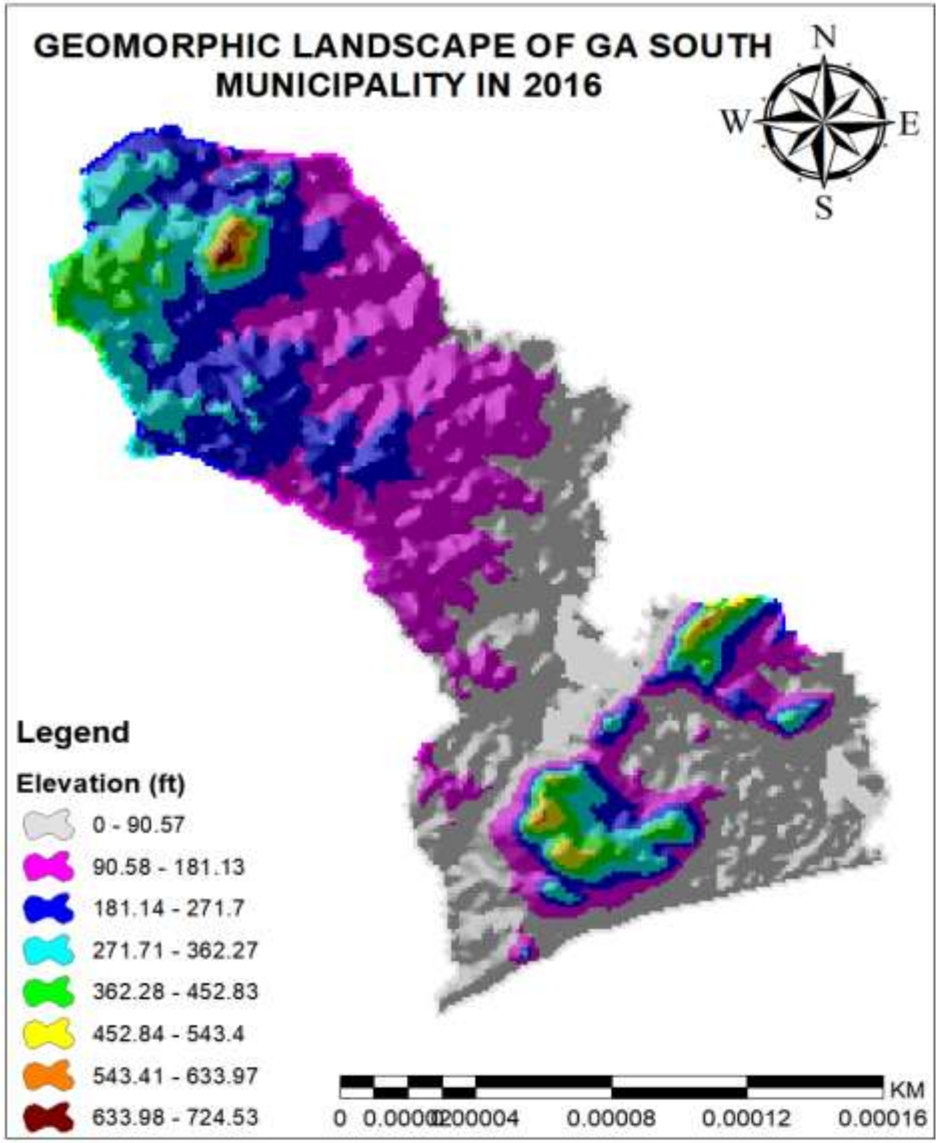


Figure 2.2: Geomorphic landscape of Ga South Municipality in 2016
Source: *ArcGIS 10.5*

Geomorphic Change Analysis between 1986 and 2018

Using the specified classification scheme in Table 4.2, the study sought to discover areas of denudation (degradation) and areas of aggradation (deposition). Evidence from the geomorphic data gathered proves that indeed every single place in the area has undergone some form of change either denudational or aggradational. The data revealed that no spot of the municipality remained unchanged in terms of elevation between 1986 and 2016. Over the 30 years period, 251 hectares of land in the municipality experienced very high degradation. This implies that 251 hectares of land had an elevation decrease below -45 feet indicating very high degradation. Places of high degradation (-45 to -30.01 feet) represented 336.3 hectares of land, while places of moderately high degradation (-30 to -15.01 feet) made up 1727.3 hectares of land. 16968.7 hectares of land was discovered to be of low degradation (-15 to 0.01 feet), which is the largest degradation class witnessed in the municipality within the study periods. In all about 19313.3 hectares of land underwent denudation which represents 56.11% of the total land area in the municipality.

Places which saw an increase in their elevations between 0.01 and 15 feet (low deposition) was 12804.8 hectares (which was the largest deposition class) whiles those with moderately high deposition (15.01 to 30 feet) represented 1588.5 hectares of land. High deposition areas (30 to 45 feet) covered 413.1 hectares of land whiles those with very high deposition (45 feet and above) represented 302.4 hectares. In total, 15108.9 hectares of land which represented 43.89% underwent some form of deposition between the study periods. It was discovered per the statistical data gathered that 86.05% of the total change in elevation was between low degradation (-15 to -0.01 feet) and low deposition (0.01 to 15 feet), while only 6.8% underwent degradation above 15 feet and 6.7% underwent deposition above 15 feet. The dynamics or changes in elevation could be attributed to the expanding activities of sand mining and quarrying as well as the rapid urban expansion in the municipality (which is proven from residential and expert interactions as well as observations carried out in some part of the municipality). Those activities in one way or the other causes either denudation or aggradation in the municipality.

Table 1.3: Elevation change classification

Elevation Change Classification and Size

Elevation Classification (feet)	Change (hectares)	Total Degradation/Deposition
Very High Degradation (Below -45.01)	251.0	
High Degradation (-45 to -30.01)	366.3	
Moderately High Degradation (-30 to -15.01)	1727.3	**19313.3 hectares (56.11%)**
Low Degradation (-15 – 0.01)	16968.7	
Low Deposition (0.01 – 15)	12804.8	
Moderately High Deposition (15.01 - 30)	1588.5	
High Deposition (30.01 – 45)	413.1	**15108.9 hectares (43.89%)**
Very High Deposition (45.01 and Above)	302.4	
No Change (0)	0	
Total	34422.2	34422.2

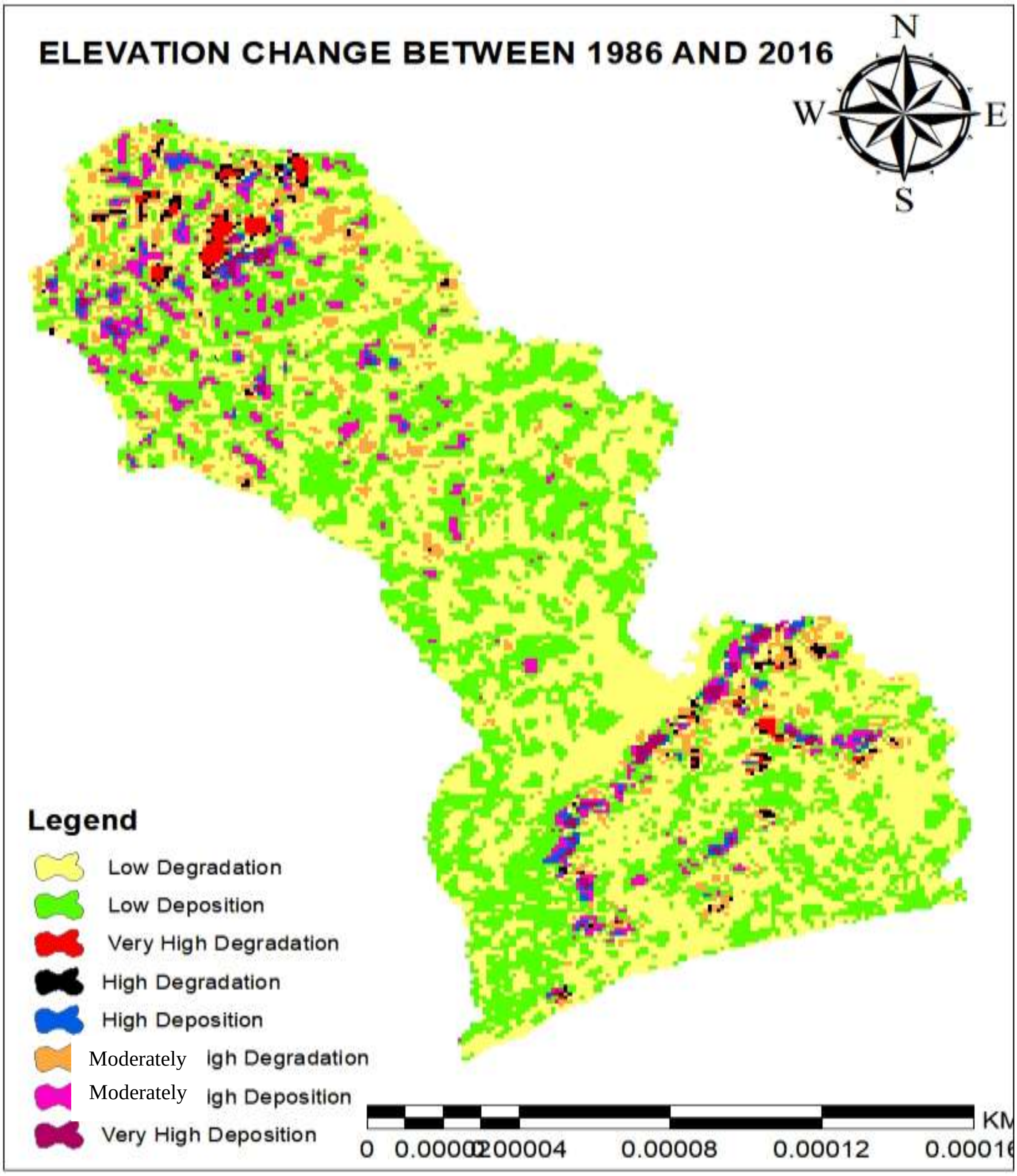


Figure 4.3: Elevation change between 1986 and 2016

4.3.2 Land Use Change Analysis

Although environmental impressions of land-cover changes are handily valued, the linkage between anthropocentric land cover change and geologic hazard isn't that self-evident. Notwithstanding, (Bassett, 2001) asserted that the political economy of globalization has influence on landscape change. Robbins (2004) was increasingly brief when he noticed that not exclusively are environmental procedures, including land-cover changes, political yet our very thoughts regarding them are likewise delimited and coordinated through socio-political and economic procedures. These incorporate the intuitive forces of demographic change, technology, level of affluence, human attitudes and values, political economy, and political structure.

Table 4.4: Change analysis between 1986 and 2003

CHANGE ANALYSIS BETWEEN 1986 AND 2003								
Class Names	**1986**	**%**	**2003**	**%**	**Change in land size**	**% Change**	**Rate of Change**	**Annual rate of Change**
BARE AREA	13301.6	38.42	11212.1	32.57	-2089.5	-5.8489398	-0.157086366	-0.009240374
VEGETATION	9408.24	27.18	6593.22	19.15	-2815.02	-8.021415	-0.299207928	-0.017600466
URBAN AREA	8036.28	23.21	13171.5	38.26	5135.22	15.0520203	0.639004614	0.037588507
WATER BODY	3874.32	11.19	3445.38	10.01	-428.94	-1.1816655	-0.110713622	-0.006512566

Table 4.5: Change analysis between 2003 and 2018

CHANGE ANALYSIS BETWEEN 2003 AND 2018								
Class Names	**2003**	**%**	**2018**	**%**	**Change in land size**	**% Change**	**Rate of Change**	**Annual rate of Change**
BARE AREA	11212.1	32.57	5556.51	16.14	-5655.59	-16.430056	-0.504418441	-0.033627896
VEGETATION	6593.22	19.15	2398.14	6.967	-4195.08	-12.187131	-0.636271806	-0.04241812
URBAN AREA	13171.5	38.26	22796.7	66.23	9625.2	27.9622257	0.730759595	0.048717306
WATER BODY	3445.38	10.01	3670.83	10.66	225.45	0.65496143	0.065435453	0.004362364

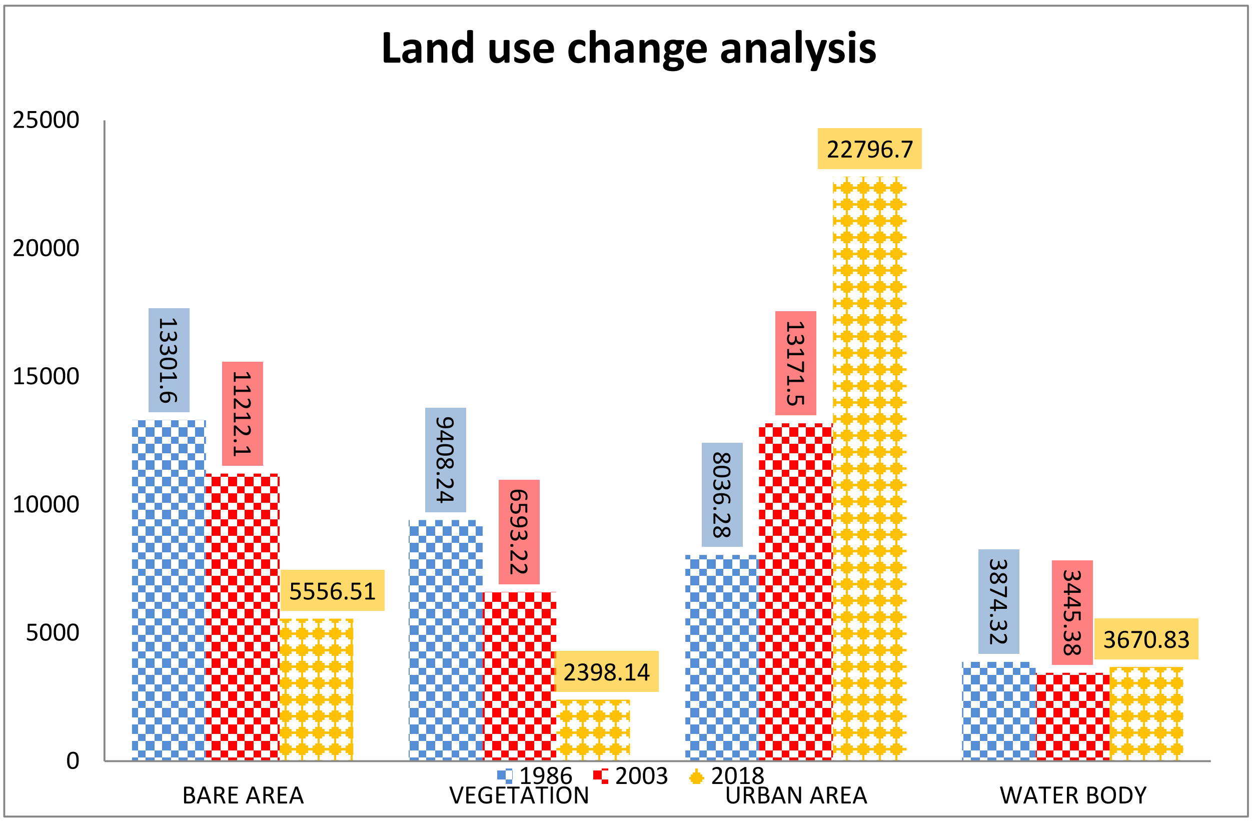


Figure 4.4: Landuse change analysis between 1986, 2003 and 2018

Source: *Field Survey, 2020*

Table 4.6: Land use change between land use classes (1986-2003 and 2003-2018)

	CHANGE BETWEEN 1986 TO 2003	CHANGE BETWEEN 2003 to 2018
Class Name	Area(hectares)	Area(hectares)
Bare Area- Bare Area	2643.57	2033.55
Bare Area –Urban Area	7113.51	8534.88
Bare Area -Vegetation	3232.89	444.33
Bare Area –Water Body	229.14	199.35
Urban Area - Bare Area	3703.5	1627.38
Urban Area - Urban Area	2473.56	10585.44
Urban Area - Vegetation	1182.06	877.59
Urban Area - Water Body	600.93	81.09
Vegetation - Bare Area	3673.62	1648.17
Vegetation - Urban Area	2842.92	3664.17

Vegetation - Vegetation	1708.74	1056.78
Vegetation - Water Body	1095.66	224.1
Water Body - Bare Area	1184.85	247.41
Water Body - Urban Area	731.88	12.24
Water Body - Vegetation	453.78	19.44
Water Body - Water Body	1495.17	3166.29

Bare area

The size of bare area in the Ga South Municipality in 1986 was about 13301.6 hectares which represented 38.42% of the total land area in the municipality. In 2003 the bare area was 11212.1 hectares which was 32.57% of the total land area. This meant a decrease of -5.85% which represented 2089.5 hectares of bare land area lost to other land use classes with a rate of change of -0.157 and an annual rate of change of -0.009240374.

In 2018, bare area further decreased from 32.57% to 16.14% representing 5556.51 hectares of land. This corresponded to 5655.59 hectares loss in bare area from 2013 with a rate of change of -0.504 and an annual rate of change of -0.034.

As evidenced from Table 4.6, between 1986 and 2003, 19.9% representing 2643.57 hectares of bare area stayed unchanged. Meanwhile it lost greatly to urban area with a land size of 7113.51 hectares representing 53.47% of its original size in 1986, while losing marginally to vegetation and water body with 3232.89 and 229.14 hectares respectively. This proves the huge influx of population into the municipality within the given period. Though it make gains from other land use classes such as urban area (3703.5 hectares), vegetation (3673.62 hectares) and water body (1184.85 hectares), its loss was far greater than its gain between the given periods (1986 to 2003).

Between 2003 and 2018, 2033.55 hectares of bare land stayed unchanged (which represents a further decrease of 610.02 from 2003). Bare area was drastically lost to urban area by 8534.88 hectares then to vegetation and water body by 444.33 and 199.35 hectares respectively. Its gain from others classes was marginal (water body (247.41 hectares), vegetation (1648.17hectares) and urban area (1627.38 hectares)) as compared to its loss to other classes.

Vegetation

In the year 1986 vegetation covered 9408.24 hectares which represented 27.18% of the total land area. The year 2003 recorded a lost -8.03% of vegetation covers leaving the municipality with 6593.22 hectares of vegetated land representing 19.15% of the total land area. This represented a loss of 2815.2 hectares of vegetated land to other land use classes representing a rate of change of -0.299 and an annual rate of change of -0.009.

By 2018, the vegetation cover had decreased dramatically by 12.19% leaving the municipality with about 2398.14 hectares of vegetated land representing only 6.97% of the total land area from its previous 19.15% in 2003. This represented a loss of 4195.08 hectares of vegetated land to other land use classes, resulting in a rate of change of -0.6363 and an annual rate of change of -0.0424.

Spanning from 1986 to 2003, 1708.74 hectares of vegetation cover stayed unchanged while tremendously losing 3673.62 (39.05%), 2842.92 (30.22%) and 1095.66 (11.65) hectares to bare area, urban area and water body respectively. It was evidence from Table 4.7 that majority of vegetated land cover was lost to bare area, which could be attributed to rapid urbanisation and urban expansion.

Between 2003 and 2018, vegetated land which went unchanged was about 1056.78 hectares, which represents a decrease of 651.96 hectares from the span between 1986 and 2003. Within this period vegetation lost 1648.17 hectares to bare area, 224.1 hectares to water body and a whopping 3664.17 hectares to urban area. Evidence from Table 4.7

shows the increasingly expanding urban and bare areas at the expense of vegetation and water body.

The high rate of vegetation lost within this period was due to the influx of residents into the area causing rapid urbanisation. Also the loss of vegetation to bare area could be attributed to the construction of the Accra-Kasoa road, which resulted in sand and stone mining in the area.

Urban Area

The municipality in 1986 had an urban land cover of 23.21% (8036.28 hectares). This land use class increased by 15.05% representing 5135.22 hectares by 2003 leaving the total urban area by 2003 at 13171.5 hectares which represented 38.26% of the total land area. This represented in a 0.639 rate of change and 0.038 yearly rate of change.

By 2018, urban area had expanded from 13171.5 hectares to 22796.7 hectares representing 27.96% increase compared to 2003, with 9625.2 hectares gain from other classes. This saw the urban area occupying 66.23% of the total land area in the municipality with a rate of change of 0.731 and an annual rate of change of 0.049.

Spanning from 1986 to 2003, 2473.56 hectares of urban land remained unchanged, while 1182.06, 3703.5 and 600.93 hectares were loss to vegetation, bare area and water body respectively. Despite the marginal loss to other classes within this year span, significant gain were made from other land use classes. 7113.51 hectares, 2842.92 hectares and 731.88 hectares were gained from bare area, vegetation and water body respectively increasing the total urban area from 23.21% in 1986 to 38.26% in 2003.

The year span from 2003 to 2018, witnessed 10585.44 hectares of urban land remaining unchanged. Within this period 1627.38 hectares was lost to bare land, 877.59 hectares was lost to vegetation and a marginal 81.09 hectares was lost to water body. The result witnessed a massive gain from other land use classes; evidenced from Table 4.6 proves that urban area made gains of 8534.88 hectares, 3664.17 hectares and 12.24 hectares from bare area, vegetation and water body respectively. This increased the total urban land size from 38.26% in 2003 to 66.23% in 2018.

Water body

The Weija Dam, River Densu, and the Pambrose lagoon are the major water bodies identified in the municipality. Water bodies covered about 3874.32 hectares (11.19%) of land in 1986 but witnessed a decrease of 1.18% representing 428.94 hectares leaving the total water body size at 3445.38 hectares representing 10.01% as at 2003. This represented a -0.111 rate of change with an annual rate of change of -0.007.

By 2018, the total water body has increased from 3445.38 hectares to 3670.83 hectares representing 225.45 hectares increase. This brought the total water body coverage to 10.66% from the previous 10.01% in 2003. This represented a rate of change of 0.065 and a yearly rate of change of 0.0044. The increase in water body within this period could be attributed to the rehabilitation of the weija irrigation scheme in 2017.

The span between 1986 and 2003 recorded 1495.17 hectares of water body remaining unchanged, while losing mainly to bare area (1184.85 hectares), urban area (731.88 hectares) and vegetation (453.78 hectares). This huge loss to bare area was as a result of hash climatic factors which cause some ponds, salt pans and other smaller rivers to dwindle and others dry up. Despite the loss to other land use classes, significant gains were made from other land use classes including bare area (229.14 hectares), urban area (600.93 hectares), and vegetation (1095.66 hectares) increasing the total water body to 3445.38 hectares at the end of 2013.

By 2018, Table 4.6 provided evidence that 3166.29 hectares of water coverage remained unchanged, while slightly losing to bare area (247.41 hectares), urban area (12.24 hectares) and vegetation (19.44 hectares). This resulted to slight gain from other land classes such as bare areas (199.35 hectares), urban area (81.09 hectares) and vegetation (224.1 hectares). This brought the total water coverage in the municipality to 3670.83 hectares as at the year 2018. This increase in water body coverage could be attributed to the 48 hectares small-scale irrigation project for small-scale farmers in the municipality, which is located around the Ashifla Zone of the municipality. Also the frequently spill of water from the Weija dam sometimes creates stagnant water and causes flood, which are sometimes classified as part of temporary water bodies.

Landuse Classification Maps

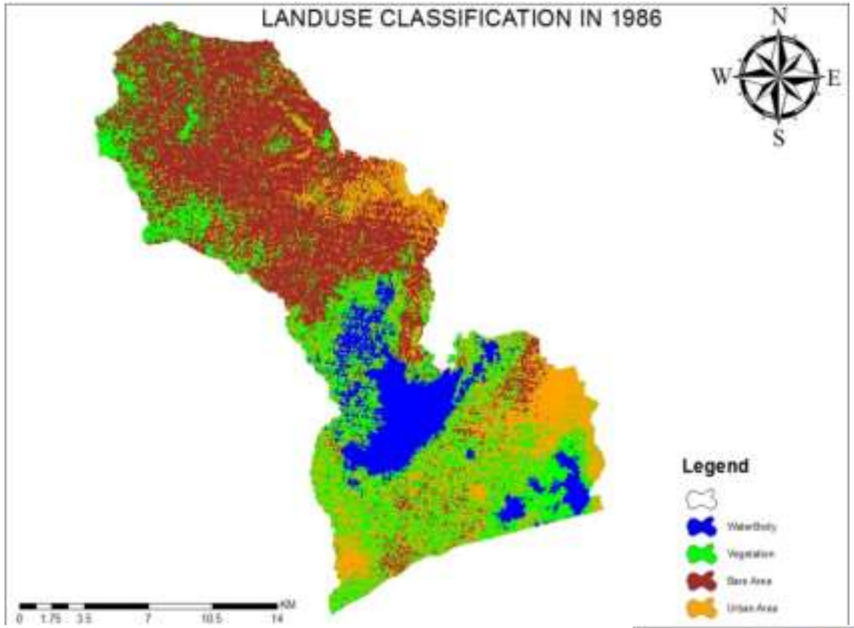


Figure 4.5: Landuse classification in 1986

Source: ArcGIS 10.5

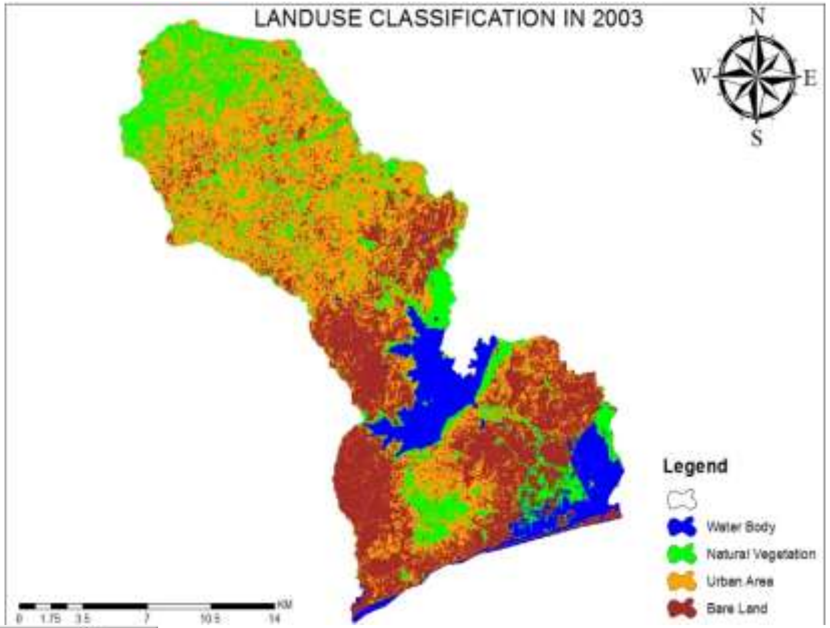


Figure 4.6: Landuse classification in 2003

Source: ArcGIS 10.5

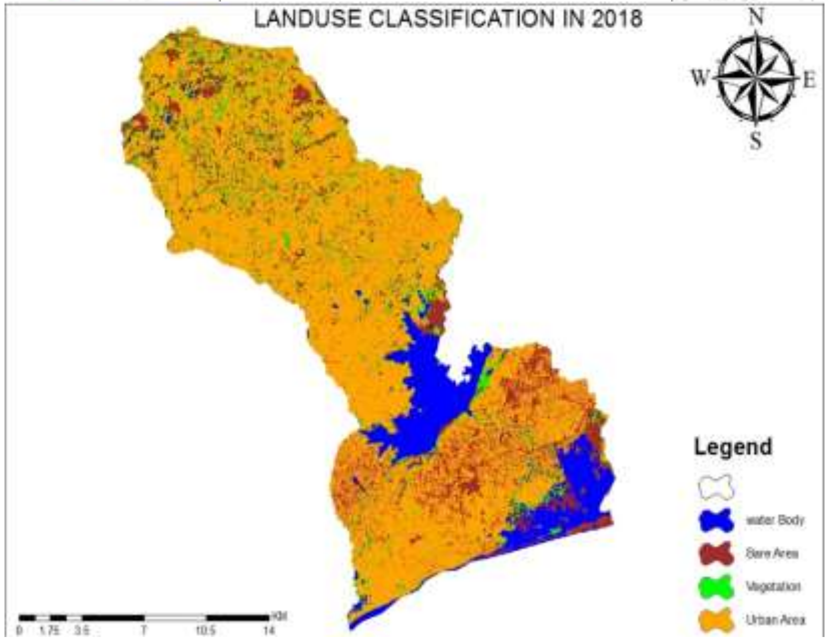
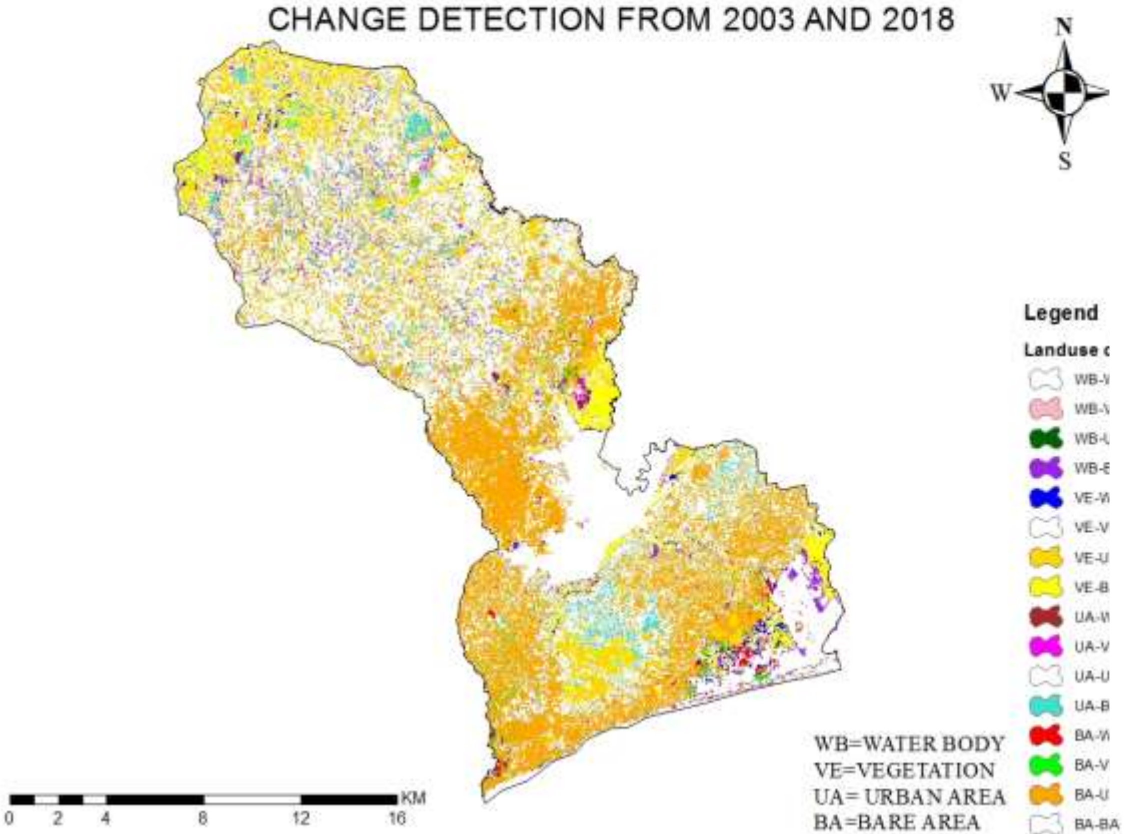


Figure 4.7: Landuse classification in 2018
Source: ArcGIS 10.5

Landuse Change Detection Maps



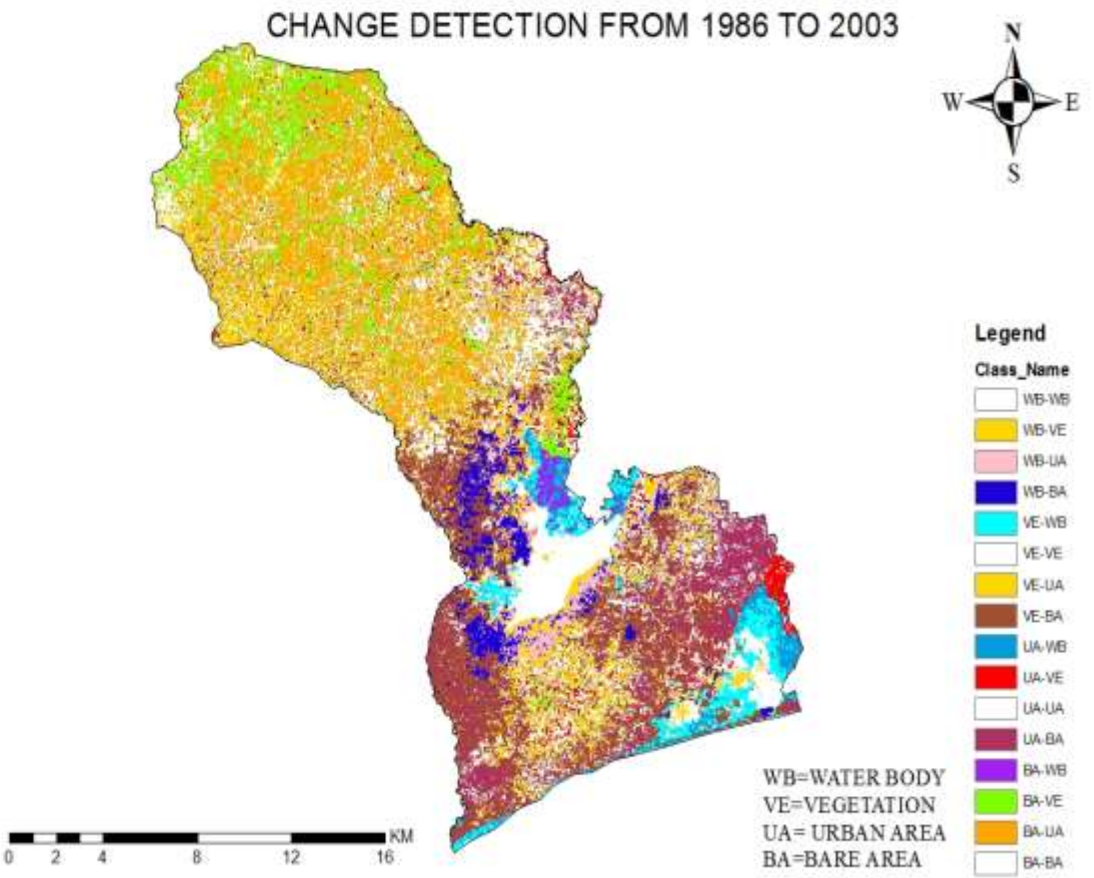


Figure 4.8: Change detection between 1986 and2003

Source: ArcGIS 10.5

Figure 4.9: Change detection between 2003 and 2018

Source: ArcGIS 10.5

4.4 Factors responsible for landscape change

The study sought to investigate the possible factors responsible for the changing landscape in the area. This objective was achieve through rigorous focus group discussion (FGD) with residents and traditional Authorities in the area, as well as interviews with environmental and geological experts including officials from the Environmental Protection Agency, the Ga South Municipal Assembly, Ghana Meteorological Agency and the Ghana Geological Survey Authority. The findings from those FGD and interviews helped to holistically determine the underlying factors responsible for the changing nature of the landscape in the study area. Some of the purported factors responsible for the changing nature of the landscape include geological factors, meteorological factors, and anthropogenic factors. Through community interaction the factors pointed out as the main causes of landscape change in the area were mainly meteorological, anthropogenic and other factors relating to policy than geological factors. This confirms the assertion of Sidle, Pearce and O'Loughlin (1985) and Guthrie (2002) that the causes of landscape change emanates mostly from human factors than geological factors. Abbott (2002) Butler (1976) and McCall (1992) believes that left with the natural factors alone, the incidence of mass wasting would be minimal globally, hence attributed the high incidence of geo hazards to human activities that serve both as preparatory as well as triggering factors. These views are captured in the expressions shared by some respondents as follows:

4.4.1 Geological factors

Interactions with respondents revealed that frequent earth tremor in the area has contributed to its tremendous landscape change. It was emphasize that the continues tremors in the area has caused instability in the earth crust and influence the continous changing nature of the lands topography. An expert respondents view about this issue of concern is expressed below:

> *''The continuous earth tremors in the area has disturbed the isotactic stability of the geological arrangement of crust particles. If these crust particles are*

disturbed they eventually cause depression and shakes in the earth's crust and influences changes in the topography of the earth.''

(EPA official, Accra)

This affirms the assertion of EPA (2018) that ''the increasing activities earth tremors is influencing tremendous landscape change as well as increasingly jeopardizing the geological stability, structure and function of most landscapes in Accra''.

4.4.2 Climatic factors

The day to day condition of the weather in the area was also attributed to influence the changing landscape in the area. The total amount of rainfall and temperature received in the area over the given period were identified to contribute to the changes in the topography of the land. In the interaction with residents and expert respondents it was emphasised that the geological nature of the loose soil in the area coupled with excessive rainfall could result in massive erosion which could also influence the changing nature of the landscape over time. This was expressed in an interview with a GMet official saying;

''the soil in the area is not compact therefore the increase in the rainfall received in the area given its location on a steep side of the hill could lead to mass wasting. These things have been witnessed in recent times, sometimes blocking the main road….''

A senior high school student who has been a resident for ten years also lamented that;

''…when it rain, the water removes all the sand from the top (pointing to an area on top of the hill) down here and to the roadside. It sometimes even blocks the road. This rains can change the looks of the landscape, even the roads here are in bad conditions….''

4.4.3 Anthropogenic factors

Respondents also expressed that human factors was one of the main factors they believe contributed to the changing landscape in the area. Respondents mentioned urbanisation, population expansion, quarrying among others as the causes of landscape change in the area. Their expression confirms the views of Hersperger and Bürgi (2009) and Lin, Wang, Wang and Wang (2015) that the reason for the intensive transformation of landscape especially in suburban areas were more human than geologic. Pereira and Pedrosa (2009) also confirmed that rapid population growth cannot be exempted from the causes of urban landscape change, since the increase demand for necessities will cause humans to expand in order to satisfy their need. Evidence of such opinions are presented in the expressions below:

> *‘‘.....ever since I settled in this area, what I can say have caused the landscape of the area to change is quarry and the way they fall down all the tress in the area. When I came here at first there were a lot of trees covering this entire place (pointing to an area/demarcation) but when the quarry started, they claim they had government permit to mine hence they came to fall down all the trees over here and started mining sand. This thing has made the landscape change over time…......’’*

(Male FGD participant, Finny Hospital)

‘‘.....you cannot take quarry out of the problem, when they finish digging the stone and sand they abundant the place and move to another place to continue digging. As soon as it rains the raining water will carry the sand left down there onto the main road and into people’s houses.’’

(Female FGD participant , Taxi rank)

Evidence of this claim is seen from plate 4.1.

Plate 4.1: Photo of an old quarry site at the last stop area
Source: Field photo, 2020

> *''....I think what causes the area to change is the influx of people into the area. Only few people stayed here when I first settled here. There was a drinking spot here as well. As time went by plenty people into the area. This has caused the rapid urbanisation leading to the erection of building and the damage of the roads.……''*

(Male FGD participant, Last Stop Area)

> *''......to the best of my knowledge you cannot excluded the rapid development of houses, roads and stores from the causes of this problem. Before all this infrastructures were built, they were once covered by vegetation, so all those vegetation were cleared in order to put up this facilities and also the building of those facilities could disturb the structure of the land and cause it to change…....''.*

(Male FGD participant, Finny Hospital)

This claim is evidence from photos taken from the field as illustrated in plate 4.2.

Plate 4.2: On-going construction works at the taxi rank area
Source: Field photo, 2020

An official from the EPA had this to say in relation to anthropogenic factors;

> *‘’……looking at the massive infrastructure development going on in the area, you cannot exclude that from the cause of the changing nature of the landscape. Thirty years ago there were few buildings around this place. The whole area was vegetated with trees and grasses all over. That vegetation played an important role in decreasing the amount of water run off during heavy down pours.....’’*

An official of the GGSA also stated that the massive evacuation of soil and stone also increases the rate of soil erosion in the area which turns to give a new shape to the geological landscape in the area. It was expressed that;

> *‘‘….when there is continues evacuation of the soil and stone from the earth, it disturbs the geological structure of the land exposing it to easy erosion anytime*

there are heavy rains…if you go to that area you will see that the excessive erosion has exposed some rocks to the surface and destroyed the road in the area. If this pattern of erosion continues for a long time it will begin to erode and expose the foundation of building especially those building closer to the road and at the steep side of the hill.

A municipal engineer also emphasised that the rapid developed and the trooping in of many people into the area has caused the changing nature of the landscape. The engineer emphasised in an expression saying;

''…at first the place was a cemetery and had only few people living there but after the development of the Accra-Kasoa road a lot of people began to settle on the hills and this resulted in the massive evacuation of the soil and rocks in order to have access to a fairly flat land to conveniently build houses…..''

These quotes confirm the assertion of Ayele et al. (2016) that population growth as well as urban expansion are the major drivers of landscape change. Yeboah, Awotwi, Forkuo, and Kumi (2017) also emphasised that the rapidly changing nature of Ghana's landscape in most part of the country could be attributed to rapid urbanisation, poor land tenure system, poor policy framework and lack of political will. They emphasised that most deteriorating landscape in urban centres were as a result of unplanned urbanisation, poor land acquisition system and poor collaboration between environmental institutions and traditional land owners.

4.4.4 Other associated factors

Poor land use policy and poor planning was also given as the cause of landscape change in the area. the nature of settlement observed in the area coupled with the nature of the roads emphasied that the residential setting lacked planning. With the exception of some few areas properly outlined, most part of the area seemed scattered and unplanned for. This emphasis the words of Yeboah et. al (2017) that the rapidly changing nature of Ghana's landscape in most part of the country could be attributed to poor land tenure system, poor policy framework and lack of political will. They emphasised that most deteriorating landscape in urban centres were as a result of poor land acquisition system and collaboration between environmental institutions and traditional land owners. Residents lamented on the nature of land acquisition and owners in the area and attributed them as part of the causes of landscape change in the area. Evidence of such opinions are presented in the expressions below:

> *''……the way and manner land is sold here is also a big problem. They sell the land for you then later officials from the assembly will come and tell you that place is a government land, later if you go and confront the chiefs, then they go and demarcate another land somewhere else for you. A friend of mine bought a piece of land from the chiefs some time ago, the portion of land they gave her was designated as a cemetery. After she built her house there out of ignorance, officials from the assembly came to notify her that the place is a cemetery but she refuse to move…..''*

(Female FGD participant, Taxi rank)

A forty year shop owner who is a resident of the area for fifteen years lamented that;

> *''…. the poor planning of the area is also one of the causes of the changes in the landscape. There is no proper planning here. Houses are built everywhere, anyhow even on the road side. If you complain, you are in trouble. Our roads are in bad shape with a lot of cracks. All the things in my shop is dusty……''*

A respondent who has resided in the area for twenty-two years lamented that;

> *''If you come to this place, things are disorganised. Look (pointing to a sand mining site close by) people's houses are here and they are digging sand and*

stones here. If they assembly plan well, they would not allow a house and a mining pit to be close like this. We always go to the hospital to treat cold and catarrh. Even if the assembly come and see they don't care, all want they come for is property rate……''

An elder in the Weija community in an interview had this to say;

''…because there is no job in the country for the youth to do when they finish JSS, they go and join the people here to dig sand and stone, that give them some small money to take care of their family and children. If there were jobs they would not go and dig to destroy the land. They know it is not good but they don't have any other way….''

'' The long land dispute between the chiefs of Gbawe and Weija surrounded by land guard disturbances which was finally settled around 2001 by a legal court system from the high court and appeal court saw the massive sales of land afterwards within the municipality. This resulted in the rapid urban and population expansion in the area.''

(An elderly FGD participant, Finny Hospital)

An official from the GGSA also lamented that;

''…the government from the onset should have zoned this area has a protected zone to prevent the sale of land and the onward development of the area…. Though the development have opened up the area, it has destroyed the natural scenery and geological beauty of the place…''

An official from the GSMA stated the one of the reasons for the changing nature of the landscape and the current problems the residents were facing there was to be attributed to the unplanned and poor land administration system entangled with the traditional authority and some family heads. He added that some portion of the area was once delineated as a cemetery but some traditional authorities and family head joined head to clear the place and sold the lands out. According to the respondent, that has made it difficult to properly incorporate the area into the development plans of the assembly.

This assertion confirms the words of Mrozik et al. (2012) and Solecka et al. (2018) that the land use policy of local authorities is also a frequent driving force of landscape change. This often leads to the degradation of historically shaped landscapes that are part of the local cultural heritage which should be protected elements in the land use policy.

4.5 Possible geological hazards

The research also sought to investigate possible geological hazard which could occur in the area. This objective was realised through experts and residents interaction. Some of the possible geological hazard stated by the respondents to be likely to occur in the area included mud flow, massive erosion, flooding, earth quake, among others. These views are captured in the expressions shared by some respondents as follows;

4.5.1 Earth tremor and Earth quake

Earth tremor seemed not new to most residents in the area. Vibrations within the earth crust was confirmed to be occurring quiet frequent in recent times. Testimonies from residents and experts revealed the fact that the area was not far from a possible earth quake in the coming days.

In an interaction with an official from the EPA it was revealed that the area had experience several earth tremors between December, 2018 and March, 2019. The official emphasied this fact through the expression that;

> *‘‘….this catchment area has experience several earth tremors between December, 2018 and March, 2019 with intensities ranging between 2.6 to 3.9. From our*

records five earth tremors were recorded within the said period, the first was on Sunday 9th December 2018 with an intensity of 2.4, the second was on Sunday 13th January 2019 with an intensity of 2.6. Twelve days after the second incidence the third tremor was witnessed on the Friday 25th January 2019 with a slightly decreased intensity to the second incidence with a 2.5 intensity… Exactly a month after the third tremor, the fourth tremor with an increased magnitude of 2.8 hits the area on 25th February, 2019. This one was much more fearful since its vibration was felt in many parts of Accra… Five days after the 2.8 magnitude tremor, the area was hit by a more fearful 3.9 magnitude tremor on Saturday 2nd March, 2019 at around 11:20pm. This was the first of the five tremors to cause destruction of some properties but luckily no lives were lost. Three muds made houses collapse around the Mile 11 hill top and Tuba area. Some properties were lost and residents in those houses were displaced as well.

It was found from the study that the frequent quarrying and sand mining coupled with the massive development in the area has caused disequilibrium in the geological structure of the rocks in the area. This claims has widened the fault line in the area and could contribute to the recent frequent earth tremors being experienced in the area. In the view of an expert official, if this continues an earthquake should be expected in no time. Some of the views in this regard is expreseed below;

‘‘......some years ago we experience a shake in the land. We were at the shop one day when all of a sudden we heard a heavy roaring sound and all of a sudden the building started shaking. We all run to the roadside to escape danger in case the building collapse. We were all afraid but it lasted only for a short period like time 10 seconds but I was very afraid I could happen again. It was later in the news that we heard that it was earth tremor but not earthquake……’’

(Female FGD participant, Last Stop Area)

''.... Though they claim this place is an earthquake prone area, we are yet to experience an earthquake. Is indeed true that we have witnessed a number of earth tremors but that will not cause us to leave our hard earned houses….Japan and Korea experience earthquake with over 7.0 to 7.4 magnitude but they haven't evacuated their country?. We are much aware this place is prone to earthquake but by the time the tremors will turn to quakes I will be died and gone long time ago (he laughed)…..'

(Male FGD participant, Finny Hospital)

A forty year old shoe maker, who had resided in the area for closely twenty-four years had this to say;

''...for the past two years we have experience about four earth shakes. The last one was in March this year; I was in my room when I heard a huge sound all of a sudden, so I come out to see what is going one. The time I come out the building start shaking. Some houses behind us witnessed cracks as other break down…''

A thirty seven year old welder also added his experience in an expression saying;

''….. I could feel the ground rumbling under my feet. Indeed, it was scary I heard an unusual sound from afar and by the time I realised my building was shaking but luckily my building didn't collapse. They said a bigger one could come very soon and that one could collapse many building so we should move but we don't have anywhere to go.''

Evidence of these assertions could be seen from field photo (plate 4.3) taken during the research showing the conditions of some building after an earth tremor witnessed in the area.

Plate 4.3: Aftermath of March, 2019 earth tremor at the hill top and last stop area
Source: Field photo, 2020

4.5.2 Flooding and Erosion

Seasonal flooding and massive erosion in the area was not new to most respondents. They claim the seasonal spillage of the Weija dam coupled with excessive rainfall erodes the soil and causes flood during the rainy season. Some residents shared their experience on flooding and soil erosion they have witnessed in the past and discussed what they could expect in the future. These views are captured in the expressions below;

> *''…. The erosion sometimes exposes pipe lines which have been buried under the ground. This could lead to their destruction and pollute the waters. During heavy down pours the running rains erodes the top soil so much that it ends up exposing major pipe lines in the area as well as destroying our roads. In some few years to come all the roads would be lost to erosion that new ones would need to be constructed.*

(Male FGD participant, Finny Hospital)

''……The way the rains use to erode soil from the top of the hills down to the road, I will not be surprised if one day erosion begins to expose the foundation of buildings and gradually collapse them….''.

(Female FGD participant, Last Stop Area)

Evidence of erosion was very visible in the municipality. Evidence from field photos proves these occurrence as shown in plate 4.4.

4.5.3 Mud flow or Soil flow

Respodents also expressed their experience on rampant mudflow in the area expecially during the rainy seasons. Residents and expert discussion revealed that mudflow was one of the most common geological hazard witnessed in the area. Residents expreesion and gestured showed emphasied that they were very worried about the rampant nature of mudflow in the area and some feared its consequency in the future. Some of these discussions are expressed below;

"The amount of rainfall being received in the district is not the major cause of the massive mudslide. Currently the district receives an average annual rainfall of 810mm, which is quite low as compared to other districts. The fact is that the vegetative over which is supposed to hold the soil together and prevent massive erosion has all been removed in the quest to have access to open space to build. Therefore any time it rains the soil is easily liquefied and quickly rushes down from the scarp, down the steep slope, pulling down the soil along with it to the lower and gentle side of the land. This results in mudflow which ends up blocking the roads and causing traffic. There might be a time in the near future where a huge one could cause a disaster……''

(GMet official, Accra)

A-Nature of road during the dry season
B-Nature of road during the rainy season
C-Loads of sand from the top of the hill blocking the main Kasoa-Accra road
D-Poor nature of roads in the community as a result of erosion
E- Erosion exposing water pipe lines

Plate 4.4: Effects of changing landscape in the study area
Source: Field photo, 2020

’‘….We use to witness huge volumes of sand moving from top of the hills to the road side when it rains heavily. This sand could sometimes block the roads for days causing huge traffic unless the Assembly bring tractors to evacuate them. Sometimes the sand can direct water into people’s houses and destroy their properties….’’

(Female participant (FGD), Finny Hospital)

Evidence of mud flow from the assertion of respondents is shown in plate 4.4c.

4.6 Landscape change projection

The study also sought to project the nature of the landscape by 2028 as the processes of denudation and aggradation continues to act on the landscape. The projection was done in two different methods [the Digital Terrain Model (DTM) and Digital Surface Model (DSM)]. The Digital Terrain Model projected changes for the next 12 years (from 2016 to 2028) while the Digital Surface Model projected changes for the next 10 years (from 2018 to 2028). The first projection was done through the Digital Terrain Model (DTM). This method emphasised on the changes in the elevation which continues in the area as the processes of denudation such as erosion, quarrying, construction etc. continues to act upon the land, changing its nature and elevation by the year 2028. The other projection was done through Digital Surface Model (DSM). This method estimated the probably changes which are likely to be realised on the surface of the landscape within the next ten year. The DSM emphasised mainly on Landuse Landcover (LULC) change analysis which made projection of changes realised in the landscape within the given period of time. The DSM projection gave a view of which landuse classification is likely to change to the other. For instance the hectares of land which changes from forest land to bare land or built-up area.

These prediction were done using the Trend Projection Analysis of quantitative forecasting. Trend analysis is a statistical technique that attempts to predict the future nature of a phenomena based on its recently observed dynamics or trend data. Trend analysis is based on the assumption that what has happened in the past gives an idea of what will happen in the future given that the current underlying conditions will continue to operate till the future (Suleiman et al., 2014).

4.6.1 Elevation change projection for 2028

Projections were made for elevation for the nest 12 years to the year 2028 using the current changing trend of elevation between 1986 and 2016. According to the projected results, about 21.04 hectares of land will fall below sea level by the year 2028 from its size of 21.6 hectares in 2016. The projection also shows that 14103.66 hectares will be between 0 to 100 feet from its size of 14114.4 in 2016, 10485.14 hectares between 100 to 200 feet from its size of 10490.5 hectares in 2016, 5860.26 hectares between 200 to 300 feet from its previous 5835 hectares in 2016, 2670.47 hectares between 300 to 400 feet from its previous size of 2669.7 hectares in 2016, 988.56 hectares between 400 to 500 feet from its size of 989.8 hectares in 2016, 228.09 hectares between 500 to 600 feet from its size of 236.2 hectares in 2016 and 64.97 hectares above 600 feet from its previous size of 64.9 in 2016. Analysis from the record shows that about 72% of the total land size will be between 0 to 200 feet above sea level.

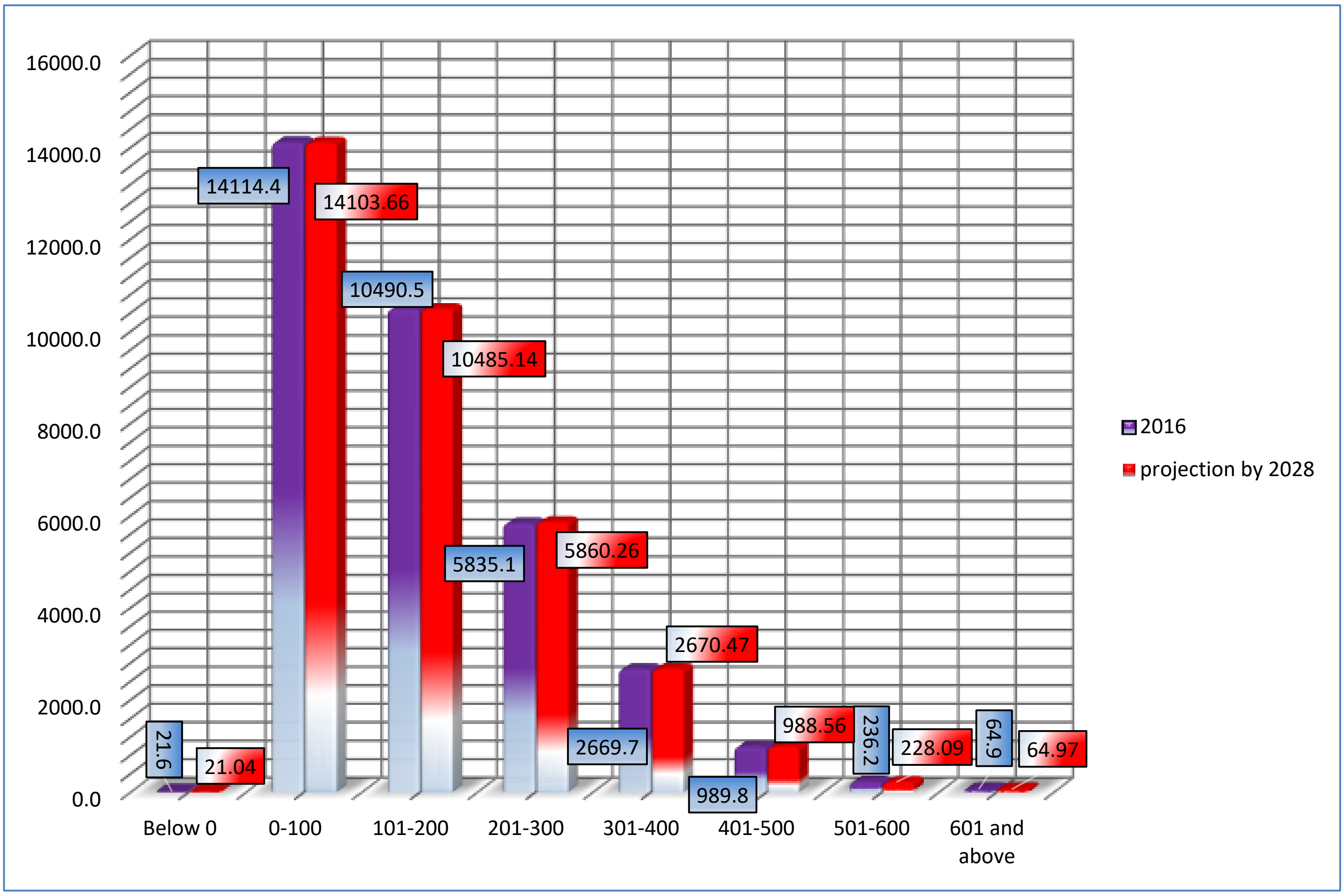


Figure 4.10: Elevation change by 2028

Source: Field Survey, 2020

4.6.2 Landuse change projection for 2028

Using the Linear Trend Analysis Prediction Model, the researcher predicted the nature of the surface landscape (landuse) by the year 2028.

Table 4.7: Landuse change prediction

Class Names	Class size in 2003	Class size in 2018	Annual change	Projected change by 2028	% change
BARE AREA	11212.1	5556.51	-377.04	1786.12	5.19
VEGETATION	6593.22	2398.14	-279.67	-398.58	-1.16
URBAN AREA	13171.5	22796.7	641.68	29213.5	84.87
WATER BODY	3445.38	3670.83	15.03	3821.13	11.10

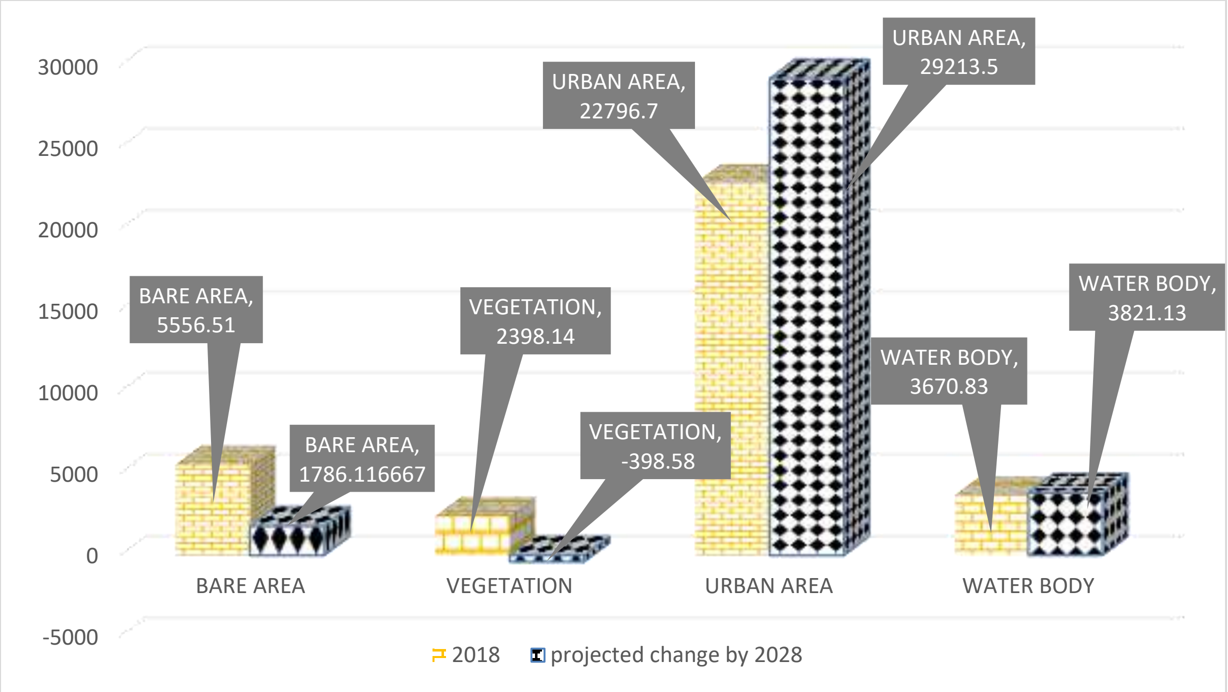


Figure 4.11: Landuse projection for 2028

Source: Field Survey, 2020

Bare Area

From the Table 4.7, the land cover for bare area in 2003 was 11212.1 hectares. This was reduced to 5556.51 hectares in 15 years (2003-2018) representing a loss of 5655.59 hectares to other classes. The annual change between 2003 and 2018 was -377.04 hectares. By the year 2028, bare area is expected to reduce further by 3770.39 hectares. By projection, the total size of bare area by 2028 is expected to reduce further to 1786.12 hectares representing a total of 5.19% of the land use in the municipality by 2028. This means few bare areas would be left in the municipality by 2028, which is likely to include tiled roads, untilled roads, expose rocks, bare parks etc.

Water body

Water coverage in 2003 was about 3445.38 hectares which represented 10.01% of the total land size in the municipality. By 2018 the municipality witnessed an increase of water coverage area by 0.65% (225.45 hectares), leaving a total water coverage area of 3670.83, representing 10.66% of total land area. The annual change between 2003 and 2018 was 15.03 hectares, giving a projected change of 150.3 hectares by the year 2028. This brought the projected water coverage area by 2028 to 3821.13 hectares, representing 11.10% of the total land area in the municipality. This implies that other land classes mainly vegetation and bare area would be possessed by water body by 2028. This additional waters might be as a results of increase in salt pan from the pambros salt company, increase flood from dam spillage or rainwater runoff etc.

Vegetation

The total land size for vegetation in 2003 was 6593.22 hectares which represented 19.15% of the total land use cover. This reduced drastically in 15 years (by 2018) to 2398.14 hectares which represented 6.97%, implying a loss of 4195.08 hectares (12.18%). The annual change between this periods was -279.67 hectares per year. This annual rate projected a change of -2796.72 hectares in the next 10 years (thus by 2028). By this, the projected vegetation cover by 2028 was -398.58 hectares representing -1.16%. This implies that there would be very little or no vegetative cover in the municipality by 2028 and even run into negatives (total vegetation lost even before the projected time). The implication of the result would be very devastating. This might not be really obvious due to the fact that green grasses continues to be used as decoration in most modern houses in the municipality.

Urban area

The total area for urban land in 2003 was 13171.5 hectares (38.26%), and was increased by 9625.2 hectares (27.97%) by 2018, leaving the total urban land at 22796.7 hectares. By this the annual change was 641.68 hectares, giving a projected change of 6416.8 hectares by the year 2028. By projection, the total urban area is expected to hit 29213.5 hectares representing

84.87% of the total land area in the municipality. This implies that other land classes such as vegetation and bare areas would be colonized by urban area leaving almost the whole municipality urbanised.

4.6.3 Implication of elevation change analysis on geo-hazards

The study also analysed the implications of the changing landscape and how it can relate to geological hazards in the area. This implication analyses focused on both elevation change analysis.

Evidence from Table 4.3 brings to discovery that as the rate of degradation increases (from low degradation through to very high degradation) the size of land affected decreases. In that same manner as the rate of deposition increases from low deposition to very high deposition the size of land affected decreases. This could contribute to the reasons why some residents do not see the intensity of the problem of elevation dynamics in the area. This is because majority of the areas which is being degraded are within low degradation hence residents see them as insignificant.

The decreasing elevation in major portions of the municipality is an evidence of the activities of sand mining and quarrying in the municipality. Slope undercutting from quarries, mines, road construction etc. depletes the area of vegetation which can weakens the geological stability of the area. Slope undercutting also increases the convexity and gradient of the slope rendering it susceptible to slope failure (UNEP, 2014). This is also confirmed by EPA in their assertion that the increase in the steepness of slopes can trigger the possibility of geo-hazard in an area (EPA, 2018).

Quarrying activities causing vibrations in the slope further weakening particle bonding, create and could expand fault lines or lines of weakness within the earth crust which could facilitate likely earth tremors and other geo-hazards such as rock fall, mudflow etc.

Above 72% of the total land area being below 200 feet implies the high proneness of the municipality to flood. The few surrounding higher lands will direct heavy rain water runoff which is not able to infiltrate into the ground to low lying areas and cause the low lying areas to flood during heavy down pour.

The adoption of the terracing system in some high raising areas in the municipality could contribute to the reshaping of the local territorial landscape. Unplanned terraced lands can make some low lying area more susceptible to the effect of mass wasting. When terrace is unmaintained and it is over saturated, it could decrease the water holding capacity of the land hence making the area more liable to mud flow in the cause of heavy rainfall. This is in line with Sidle, Pearce, and O'Loughlin (1985) claims that the significance of soil stability are those that influence the rate of water movement in soil and the capacity of the soil to hold water, hence its failure can lead to mud flow.

4.6.4 Implication of landuse change on geological hazards

The study also analysed the implications of the changing landscape and how it can relate to geological hazards in the area. This implication analyses focused on land cover change.

The increasing urban expansion in the municipality could pose a risk of geological hazard. The heavy weight mounted on slopes due to construction activities, coupled with the cutting of the slope basement (terracing) increase the stress level of the slope (Abbott, 2002). This incidence could lead to a possible geo-hazard in the area.

The projected loss of vegetation to other land class type will mean a threat to rivers and other water bodies in the area. As vegetative cover is lost in the municipality, many rivers and water body such as the Weija Lake, pambros lagoon and the Densu River would be exposed to the high threat of direct sun radiation and climate change effect which would result in the loss of aquatic diversity.

The loss of vegetative cover will expose the bare area to excusive sun radiation hence evaporating soil moisture easily. It will also reduce the rate of the soils' water saturation capacity making the bare ground very hard and solid hence increasing the rate of water runoff through reduced infiltration during rains and dam spillage. This could lead to flash flood in most part of the municipality. Vegetation can intercept rainfall and reduce the rate of runoff in the municipality. Leaves and stems can capture rain and prevent it from over saturation of moist soil. Dense vegetative cover can help prevent excessive runoff during heavy precipitation saving the municipality from flooding but the absence of vegetation per the projection would make the district more liable to flood.

Vegetative cover reduces the speedy flow of water runoff from the surface of the soil, thus preventing excess erosion. The absence of this vegetative cover as projected be the research could mean an increase in the rate of erosion thus exposing building foundations which could lead to their collapse, destroying roads and exposing buried utility line to the earth surface thus exposing them to threat such as pipe borne water pollution.

High saturated sandy loamy soil coupled with excessive rainfall at peak rainy seasons can trigger the inclination of mud flow in high elevated areas including the study area.

Vegetation loss within the Municipality poses a serious threat to natural habitats, hence affecting the biodiversity of the district landscape. When vegetation cover is lost it deprive some organisms of their place of habitat hence leading to their extinction. The increasing issues of vegetation depletion for building have eroded most of the original biodiversity over the past decades in the study area.

The abundance of fauna on land is mostly measured by the magnitude of plant cover (Butler and Van Soest, 1996). The loss of vegetation will hence mean the reduction in micro and macro organisms which are responsible for aeration and provision of nutrients for the soil to boosting agriculture productivity. This will decrease the productivity level of farmers in the municipality, hence will motivate then to venture in earth depletion practices such as sand mining and quarrying, which in the long term could led to geo-hazards.

The rapid urbanisation of the municipality means a rapid increase in construction of houses and other social amenities in the area. This will imply the continuous disturbance of the structural geology of the area hence the high possibility of triggering likely geological hazards such as earthquake, rock fall, mud flow, etc. This affirms the assertion of Abbott (2002) that heavy weight mounted on slopes due to construction activities coupled with the cutting of slope basement increase the stress level of the slope which could cause geo-hazard.

Uncontrolled rapid urbanisation in the municipality coupled with the pavement of most houses in contemporary housing will mean a low rate of precipitation infiltration, hence leading to increase runoff which could cause devastating flood anytime there are heavy rains.

Rapid urbanisation leading to population explosion in municipality coupled with the high rate of unemployment in the municipality could lead to most of the well abled youth involving themselves in sand mining and stone quarrying. The continues influence of these activities could contribute to the devastating change of the landscape hence rendering the area more susceptible to geological hazards due to the geological equilibrium disturbances which would be created over time.

4.7 Relationship between study and conceptual framework

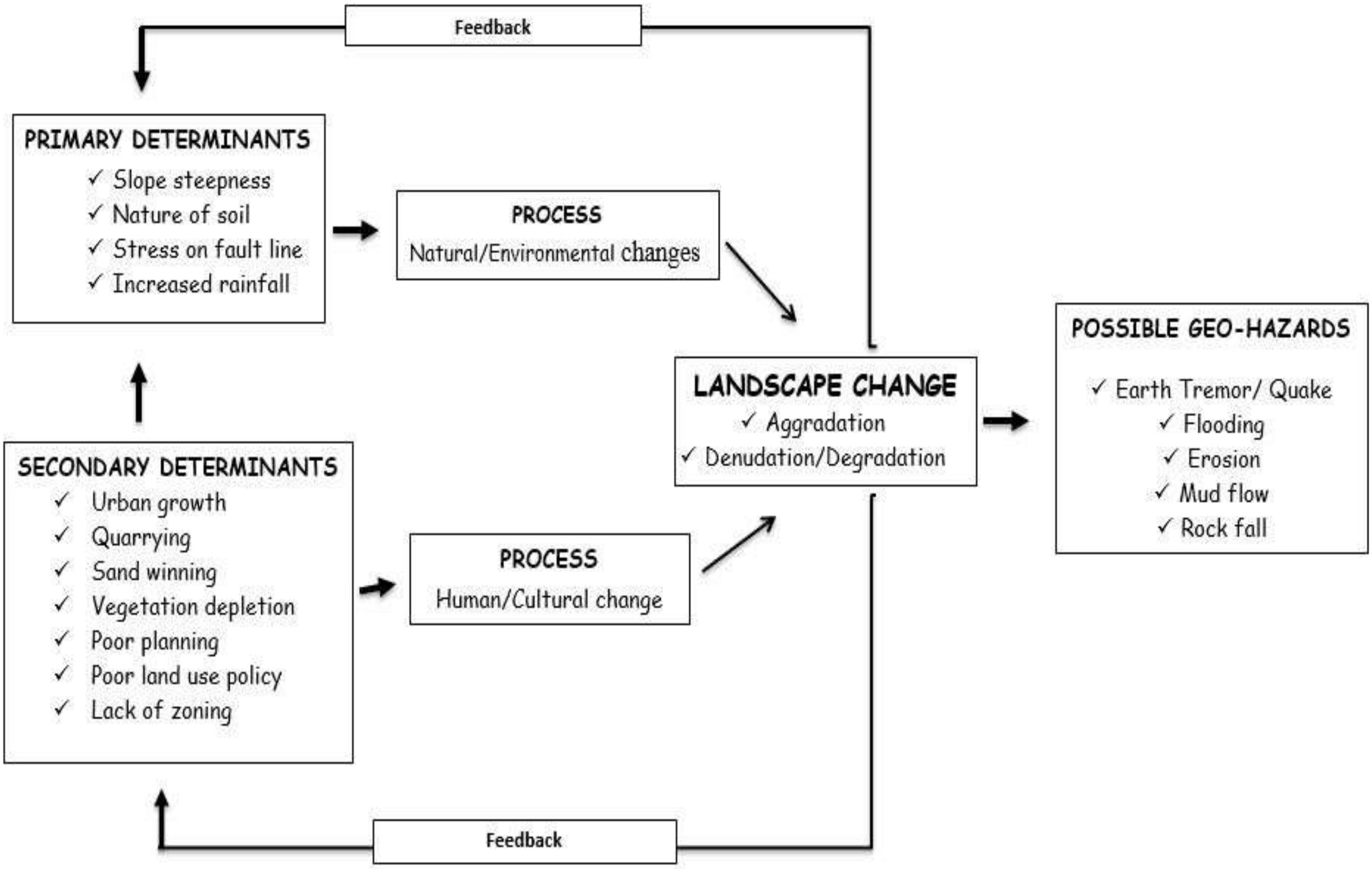


Figure 4.12: Relationship between study and conceptual framework
Source:Field Survey, 2019

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The findings from the analysis and discussions of data in the previous chapter have been summarized in this chapter. The chapter thus presents on the summary of findings and recommendations made to improve on a sustainable landscape and prevent potential devastating geo-hazards as the processes of diastrophism continuously act on the landscape.

5.2 Summary

The research was conducted to investigate the dynamics of landscape and possible geological hazards in the Ga South municipality. The research examined the extent of landscape change in the study area and projected the geological nature of the study area by the year 2028. The research adopted cartographic techniques which combined remote sensing and Geographical Information Science (GIS), with cartographic analysis at different spatial time scales. The research investigated the phenomenon between 1986 and 2018 using the sequential explanatory case study design. Digital data set of elevation data for the years 1986 and 2016 and remote sensing images for the years 1986, 2003 and 2018 was derived from Google earth and the United States Geological Survey (USGS) official website (www.earthexplorer.usgs.gov). The maps were manipulated using ArcGIS 10.5 (ESRI, 2002) and ERDAS IMAGINE 2013 and changes were analysed. In addition, 32 respondents were purposively selected for community and expert interactions. Analyses on landscape change were done on elevation change and land cover change. These were done to determine the magnitude of landscape change in the study area. Projections were also made for elevations change and land cover change for the next decade. Cartographic images, photos, maps and graphs were used to present the data.

5.3 Main Findings

- Geomorphic change in the municipality could be hugely attributed to anthropogenic factors rather than geological factors.
- The dynamics of elevation could be attributed to the expanding activities of sand mining and quarrying as well as the rapid urban expansion in the municipality.
- The study discovered that there was more degradation than deposition between the study periods. About 19,313.3 hectares of land underwent denudation which represents 56.11% of the total land area while 15,108.9 hectares of land which represented 43.89% underwent deposition.
- The research discovers that about 72% of the total land area will fall below 200 feet which implies the high proneness of the municipality to flood. The few surrounding higher lands will direct heavy rain water runoff which is not able to infiltrate into the ground to low lying areas and cause the low lying areas to flood during heavy down pour.
- The decreasing elevation in major portions of the municipality is an evidence of the activities of sand mining and quarrying. Slope undercutting from quarries, mines, road construction, dams and reservoirs deplete the area of vegetation and also weakens the geological stability of the area. Quarrying activities causing vibrations in the slope further weakening particle bonding and create and expanding lines of weakness within the earth crust could facilitate likely earth tremors and other slope failure related geo-hazards such as rock fall, mudflow, etc.
- Poor land administration system was also identified as one of the drivers of landscape change in the area.

- The adoption of the terracing system in some high raising areas in the municipality could contribute to the reshaping of the local territorial landscape. Unplanned terraced lands can make some low lying area more susceptible to the effect of mass wasting.
- The increasing urban expansion in the municipality could pose a risk of geological hazard. The heavy weight mounted on slopes due to construction activities coupled with the cutting of the slope basement (terracing) increase the stress level of the slope which could lead to a possible slope failure in the area.
- The high rate of vegetation lost within the period could be attributed to the influx of residents into the municipality causing rapid urbanisation. Also the loss of vegetation to bare area could be attributed to the construction of the Accra-Kasoa road, which resulted in sand and stone mining in the area.
- Vegetation can intercept rainfall and reduce the rate of runoff in the municipality. Leaves and stems can capture rain and prevent it from over saturation of moist soil. Dense vegetative cover can help prevent excessive runoff during heavy precipitation saving the municipality from flooding but the absence of vegetation per the projection would make the district more liable to flood.
- Possible geological hazards which is envisaged in the area includes earth quake, landscape influenced flooding, mudflow and landslide.

5.4 Conclusions

Landscape change is undoubtedly linked with anthropogenic activities. Due to readily available land in some mountain areas residents use it intensively without the thought of sustainability and hazard risk. The current land-use model in the Ga South Municipality is undoubtedly not sustainable. The rate at which the landscape is adversely changing is not compatible with sustainable landscaping. A massive afforestation project should be adopted to balance the vegetation disturbance and rapid loss to a more sustainable rate to aid attain landscape equilibrium. Radical steps should be taken by the national government and municipal assembly to evacuate and relocate residents in the area in order to prevent any possible future effect of geological hazard that might hit the area.

5.5 Recommendations

The recommendations are made dependent on the discoveries and the ends drawn:

- The Ga South Municipal Assembly should introduce livelihood strategies to incorporate other pay sources outside sand mining and quarrying that can give more incentive than geologic depletion based occupations.
- The Ga South Municipal Assembly needs to attempt an enormous afforestation to increase vegetative cover in the district.
- There should be a proper coordination between traditional land owners, EPA, GGSA and the GSMA towards the acquisition and sales of land to enhance proper planning in the Municipality.
- Government through the Municipal Assembly should zone hazard prone areas and relocate residents to prevent future risk and fatalities.
- To limit the negative effects of land-cover changes on urban biological systems in the municipality, it is prescribed that the Ga South Municipal Assembly should introduce an urban development policy in the area. The focal point of this strategy should be the maintenance a reasonable balance between urban infrastructure development, ecological sustainability, and geological sustainability.

- Government through constitutional procedures should develop the capacity of government institutions responsible for public land administration and development while harmonizing their functions under a solitary administration authority. This could be relied upon to improve the effective administration of land throughout the country.
- Finally, to control geological hazard, conscious efforts ought to be made at the national, regional, and district levels to develop comprehensive land-use plans to guide urban land management. As a feature of housing policy, vertical development of housing and office accommodation should be encouraged as opposed to horizontal expansion of private convenience, which could encourage further sprawl developments.

5.6 Areas for Further Research

The following topics are suggested for further research in the municipality.

- Landscape dynamics and aquatic species extinction in the Weija Lake.
- The impact of erosion on the livelihood of residents in the Ga South Municipality.
- Landscape dynamics and its influence on the water quality of the Weija lake in the Ga South Municipality

REFERENCE

Abbott, P. L. (2002); *Natural Disasters*. Boston; McGraw-Hill

Acosta T. V, Schildgen T. F, Clarke B. A, Scherler D, Bookhagen B, Wittmann H, Blanckenburg F, and Strecker M. R(2015), *Effect of vegetation cover on millennial-scale landscape denudation rates in East Africa*, ResearchGate.

Adu, T.K., (19/06/2015). Potential hazard in waiting. Daily Graphic pp. 9

Alexander, D. (1993). *Natural Disaster*, London, University College Library Press.

Ambraseys, N.N. & Adams R.D (1986) "*Reappraisal of Major African earthquakes south of 20 N 1900-1930*" *Natural Hazards*, Vol. 4 No 4, pp. 389-419.

Amponsah, P. E (2004) *Seismic activities in Ghana: past, present and future*, *Annals of Geophysics*, Vol. 47 No 2/3 pp. 539-43.

Amponsah, P.E. (2002). *Seismic activities in relation to fault systems in Southern Ghana*. *Journal of African Earth sciences,* Vol. 35 pp. 227-34.

Anbalagan R, and Singh B (1996) Landslide hazards and risk assessment mapping of mountainous terrains - a case study from Kumaun Himalaya. India, Engineering Geology 43: 237-246.

Andoh R.Y.G. & Declerck C., (1999), Source control and distributed storage – a cost effective approach to urban drainage for the new millennium, *Proc. 8th Int. Conf. Urban Storm Drainage*, Sydney, Australia, 30 August–3 September, pp. 1997–2005.

Andrew L., (2013, June 24). Alberta Floods: Assessing the human, environmental and economic impacts. The Toronto Star. Retrieved from (http://www.thestar.com/news/canada/2013/06/24/alberta_floods_assessing)

Antrop M. (2006), Sustainable landscapes: contradiction, fiction or utopia? Landscape Urban Planning, 75, 187–197.

Antrop, M (2005), why landscapes of the past are important for the future? Landscape Urban Planning 70:21–34

Antrop M. (2004), Landscape change and the urbanization process in Europe. Landscape Urban Planning, 67, 9–26.

Antrop M. (1998) Landscape change: plan or chaos, *Landscape and Urban Planning*, 41, pp.

Antwi E.T., Boakye-Danquah J., Asabere S.B., Yiran G.A.B.,*4, Seyram K.L., Awere K.G., Abagale *F.K..,* Asubonteng K.O., Attua M.E., Owusu A.B. (2014). Land Use and Landscape Structural Changes in the Ecoregions of Ghana. Journal of Disaster ResearchVol.9 No.4, 2014

Asante, K.A., Quarcoopome, T., and Amevenku, F.Y.K, (2008). Water quality of the Weija Reservoir after 28years of impoundment. *West Afrian Journal of Applied Ecology*. Vol. 13 2008: pp. 125-131

Ayele, G.T., Demessie, S.S., Mengistu, K.T., Tilahun, S.A., Melesse, A.M. (2016). Multitemporal land use/land cover change detection for the Batena Watershed, Rift Valley Lakes Basin, Ethiopia. In: Melesse, M.A., and Abtew, W., eds. Landscape Dynamics, Soils and Hydrological Processes in Varied Climates. New York, NY: Springer International Publishing; 2016:51–72.

Baena, E. R, Guerrero, A. I., & Janský, B. (2006). Comparative analysis of the floods in Prague (Czechia) and in Seville (Spain): Seed from the geographical viewpoint. Geografie – Sborník ČGS, 111(3), 326–340.

Bassett, T. J. (2001). The Peasant Cotton Revolution in West Africa: Coˆte d'Ivoire 1880–1995. Cambridge University Press, 268 pp

Bennett, M .R. & Doyle, P (1997). *Environmental Geology-Geology and the human environment.* Chichester: John Wiley & Sons Ltd.

Bertrand, G., (2004), "Paisagem E Geografia Física Global – Esboço Metodológico," *Revista RA´E GA – O Espaço Geográfico em Análise*, 8, 141–152.

Bhattacherjee A. (2012). Social Science Research: Principles, Methods, and Practices, Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License

Bryant, E. A. (1991). *Natural Hazards*, Cambridge, Cambridge University Press.

Bürgi M, Hersperger A. M, & Schneeberger N., (2004) Driving forces of landscape change current and new directions. Landscape Ecology 19:857–868

Butler, E. H. & Van Soest D.P, (1996). *A note on High Discount Rates and depletion of the tropical Forests. Journal of Agricultural and Research Economics.* 21: 341-350

Butler, J. (1976) *Natural Disasters*, Victoria, Heinemann.

Catane, S. G., Cabria, C. P.J., Tomarong, R., Saturay M., Zarco M.A.H., and Pioquinto W.C (2006). *Catastrophic rock-debris avalanche at St. Bernard, Southern Lyete, Philippines*. Landslides: DOI: 10.1007/s10346-0050-3.

Clark, J. J and Wilcock, P. R., (2000). *Effects of landuse change on channel morphology in northeastern Puerto Rico. Geological Society America Bulletin* 122, no.12 p.1763-1777.

Coch, K. C (1995) *Geohazards: Natural and Human*, New Jersey Prentice Hall Inc.

Conservation International (2011), Crystal Drive Arlington, VA 22202 http://www.conservation.org

Corominas, J. Remondo, J. Farias, P. Esterao, M. Zezere,T. Dias de Teran, J. Dikan, R. Schott, L. Moya, J. and Gonzalez, A. (1996). Debris flow, *International Association of Geomorphologists* 5, 61-180.

Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions.* Thousand Oaks, CA: Sage Publications.

Crozier, M. J. (1984) *Field Assessment of Slope Instability in D Brunsden and D Prior (eds) Slope Instability*, New York, John Wiley and Sons Ltd.

Cruden, D., (1991.) *A simple definition of landslide*. *Bulletin IAEG.* 43: 27-29.

Daily Graphic, (8 June, 2019). Mudflow after heavy rain. Daily Graphic pp. 12

Dawson, J. (1983) Geography (Sevenoaks, Hodder & Stoughton)

Dodouras S, Papayannis T. & Sorotou A., (2009). In search for the Greek landscapes: current trends and future concerns.In: J. Breuste, M. Kozov & M. Finka (eds.): *European Landscapes in Transformation: Challenges for Landscape Ecology and Management, European IALE Conference,* Salzburg (Austria), Bratislava (Slovakia), 37-40.

Dunning S.A., Mitchell W.A., Rosser N.J and Petley D.N (2007). *The Haitian Bala rock avalanche and associated landslides triggered by the Kashmir Earthquake of 8 October 2005. Engineering Geology* 93(3-4): 130-144.

EC Joint Research Centre Technical Report (2014). Revision of Green Public Procurement Criteria for Road construction. Available online: http://susproc.jrc.ec.europa.eu/road/docs/1AHWG_GPP_road_draftTechnicalReport_v1.pdf (accessed on 30 April 2019).

Ellis, E. (2013). *Land-use and land-cover change*. Retrieved (11/11/2019) from http:www.eoearth.org/view/article/154143

Environmental Protection Agency (2018). EPA Year in Review 2017-2018 report

https://www.epa.gov/sites/production/files/201803/documents/year_in_review_3.5.18.pdf

Farina, A. (2006), Principles and methods in landscape ecology, Dordrecht, the Netherlands: Springer.

Finka, M, Kozová, M. & D. Petríková (2009). Transforming landscape interactive processes between landscape and society in central Europe, In: J. Breuste, M. Kozov & M. Finka (eds.): *European Landscapes in Transformation: Challenges for Landscape Ecology and Management, European IALE Conference,* Salzburg (Austria), Bratislava (Slovakia), 45-48.

Finlay, P. And J.F. Robin (1997) *Landslide Risk perception and acceptance*. *Geotech.* J.34:169-188 Canada

Forman, R.T.T and Godron M. (1981), Patches and structural components of a landscape ecology. Bioscience 31(10): 733-740

Forman, R.T.T and Godron M. (1986), landscape ecology, Wiley, New York

Frimpong, A. (2011). *Application of Remote Sensing and GIS for Forest Cover Change Detection (A case study of Owabi Catchment in Kumasi, Ghana)* M.Phil Thesis, KNUST.

Frimpong, E. (2007). Landuse and landscape issues in Ghana. retrieved on 20/08/2019 from http//www.enochdarfahfrimpong.blogapot.com

Geitner, C. and Tusch M., (2009). How can soils and their natural performances be considered adequately in planning procedures? – Concepts and tolls for project SEPP. In: J. Breuste, M. Kozov & M. Finka (eds.): *European Landscapes in Transformation: Challenges for Landscape Ecology and Management, European IALE Conference,* Salzburg (Austria), Bratislava (Slovakia), 49-53.

Gennaio, M.P. & Hersperger A.M., (2009). Political driving forces of urban change in three Swiss municipalities, In: J. Breuste, M. Kozov & M. Finka (eds.): *European Landscapes in Transformation: Challenges for Landscape Ecology and Management, European IALE Conference*, Salzburg (Austria), Bratislava (Slovakia), 54-56.

Ghana Statistical Service (2013), *2010 population and housing census*, a summary of special report on urban localities, Accra, Ghana.

GhanaWeb, (2017/11/18). Landslide Disaster looms at Ablekuma, Kasoa and Ofankor. https://www.ghanaweb.com/GhanaHomePage/NewsArchive/Landslide-Disaster-looms-at-Ablekuma-Kasoa-Ofankor-601868

Goltz, (2003). *Goltz, Elizabeth, retrieved May 27, 2018, from University of Wisconsin-Madison. Department of Geoscience*: http://www.geology.wisc.edu/courses/g155/projects03/emgoltz/definition.htm.

Guthrie, R. H. (2002). *The effects of logging on the frequency and distribution of landslides in the three watersheds on Vancouver Island, British Colombia*. *Geomorphology* 43, p.273-292.

Hanson, H., Aarninkhof, S., Capobianco, M., Jiménez, J. A., Larsom, M., Nicholls, R. J., Plant, N. G., Southgate, H. N., Steetzel, H. J., Stive, M. J. F. & de Vriend, H. J., (2003). Modelling coastal evolution on yearly to decadal time scales. *Journal of Coastal Research*, 19(4) 790 – 811.

Hawkson, E.E., (8/04/2014). Measures to protect Weija dam needed. Daily Graphic. Pp 14

Hersperger, A.M. & Bürgi, M. (2009). Going beyond landscape change description: Quantifying the importance of driving forces of landscape change in a Central Europe case study. Land Use Policy, 26, 640–648.

Hurni, H, Wiesman, U. M., (2010). *Global Change and Sustainable Development: A Synthesis of Regional Experiences from Research. Bern*, Switzerland: Geographica Bernesia; 2010:187–207.

Ige O. O., Oyeleke T. A., Baiyegunhi C., Oloniniyi L. T., and Sigabi L.,(2016). Liquefaction, landslide and slope stability analyses of soils: A case study of soils from part of Kwara, Kogi and Anambra states of Nigeria. Nat. Hazards Earth Syst. Sci. Discuss., doi: 10.5194/nhess-2016-297, 2016.

Inganga, S. F, Ucakuwum, E. K and Some, D. K. (2001) *Rate of swelling of expansive soils; a critical factor in the triggering of landslides and damage to structures*. Documenta Naturae 136, 93-98.

Johnson, M. A and Rodine, J. R (1986) *Slope Instability*, New York, John Wiley and Sons Ltd.

JoyNews, (2018/11/26). Danger: EPA raises alarm over potential for weija ridge collapse https://www.myjoyonline.com/news/2018/November-26th/danger-epa-raises-alarm-over-potential-for-weija-ridge-collapse.php

Juventine E. J (2012). *Landslide Hazards: Household Vulnerability, Resilience and Coping in Bududa District, Eastern Uganda*. Disaster Management Training and Education Centre for Africa. University of the Free State.

Kasulo, V. (2005) *Forest Resources Accounting for Improved National Income Accounts of Malawi, A Presentation at the First Technical Training and Research Workshop on Environmental Accounting Under Phase III of the Natural Resource Account in Eastern Africa Project, Maputo, Mozambique,* 12-16 June 2005.

Kitutu, M. G., Muwanga, A. Poesen, J and Deckers J. A, (2009) *Influence of soil properties on landslide occurrences in Bududa district, Eastern Uganda, African Journal of Agricultural Research* Vol. 4 (7), pp.611-620, Available online at http://www.academicjournals.org/AJAR ISSN 1991-637x.

Kjekstad, O. & Highland, L. (2009). *Economic and social impact of landslides. In Sassa K. & Canuti, P. (Eds). Landslides – disaster risk reduction*, Springer–Verlag Berlin Heidelberg.

Knapen, J. Kitutu, M. Poesen, J.Brengelmans, W. Deckers, J. and Muwanga, A. (2006*) Landslides in Densely Populated County at the Foot Slope of Mount Elgon (Uganda): Characteristics and Causal Factors, Geomorphology* 73, 149-165.

Krajewski, P. (2017). Landscape change index as a tool for spatial analysis. J. IOP Mater. Sci. Engin, 245, 072014.

Kristensen, S.B.P., (2009). Managing rurban landscapes in the Netherlands, Denmark and Sweden: comparing planning systems and instruments in three different contexts. In: J. Breuste, M. Kozov & M. Finka (eds.): *European Landscapes in Transformation: Challenges for Landscape Ecology and Management, European IALE Conference,* Salzburg (Austria), Bratislava (Slovakia), 57-61.

Kupidura. A., Kupidura P. & Golab U., (2009). Analysing land use changes on urban fringe using remote sensing and GIS technology – Lomianki case study. In: J. Breuste, M. Kozov & M. Finka (eds.): *European Landscapes in Transformation: Challenges for Landscape Ecology and Management, European IALE Conference*, Salzburg (Austria), Bratislava (Slovakia), 125-127.

Larsen, M. C & Torres-Sanchez, A. J. (1998). *The frequency and distribution of recent landslides in three montane tropical regions of Puerto Rico*. *Geomorphology* 24, p. 309-331.

Lavell A. (1994). *Prevention and mitigation of disasters in Central America*: vulnerability to disasters at the local level. Disasters, Development and environment. A. Varley. Chichester: John Willey and Sons: 49-63.

Leopold, L.B. (195I). 'Rainfall frequency: an aspect of climatic variation', Trans. Am. geophys. Un. 32, 347-57

Lin, X., Wang Y, Wang S. & Wang D., (2015). Spatial differences and driving forces of land urbanization in China. J. Geogr. Sci., 25, 545–558.

Ludman, A. and Koch, N. I (1982) *Physical Geology*, London McGraw-Hill Book Company.

Matsushi, Y., Httanji, T., and Matsukura, Y. (2006). *Mechanics of shallow Landslides on soil mantled Slopes with Permeable and Impermeable Bedrock in Boso Peninsula, Japan, Geomorphology* 76, 92-108.

McCall, G. J. H. (1992). *Geohazards "Natural and Man –Made*" London, Chapman and Hall.

Ministry of Lands and Forestry (1999). "Managing Ghana's wetlands: a national wetlands conservation strategy"

Morse, J. M. (1994). Designing funded qualitative research. In Denizin, N. K. & Lincoln, Y. S., *Handbook of qualitative research* (2nd Ed). Thousand Oaks, CA: Sage

Mrozik, K., Bossy, M., & Zareba, K., (2012). Polityka przestrzenna gmin wiejskich na tle zmian zagospodarowania przestrzennego wynikaja˛cych z suburbanizacji. Rocznik Ochrona S´rodowiska, 14, 761–771.

Msilimba G. G., (2007). *A Comparative Study of Landslides and Geo-hazard Mitigation in Northern and Central Malawi*. University of the Free State

Msilimba, G. G., and Holmes, P. J., (2005). *A Landslide Hazard Assessment and Vulnerability Appraisal Procedure; Vunguvungu/Banga Catchment, Northern Malawi*. *Natural Hazards* 34, 199-216.

Myers, D. (1997). Qualitative research in information systems. The University of Auckland. www.qual.auckland.ac

National Academies Press (2010). Grand Challenges in Earth Surface Processes: Landscapes on the Edge: New Horizons for Research on Earth's Surface. https://www.NAP.edu/10766

National Geographic Resource Library (n.d): encyclopaedic entry, National Geographic Society Organization. Accessed on 18/04/2019 https://www.nationalgeographic.com/science/earth/the-dynamic-earth/weathering-erosion/?beta=true

Nott J., & Roberts G. R., (1996). Time and process rates over the past 100 m.y.: A case for dramatically increased landscape denudation rates during the late Quaternary in northern Australia, *GeoSCienceWorld: The Geological Association of America, Geology* 24 (10): 883-887.

Orme, Anthony R. (2007). "The Rise and fall of the Davisian Cycle of Erosion: Prelude, Fugue, Coda, and Sequel". *Physical Geography*, 28 (6): 474–506. Doi:10.2747/0272-3646.28.6.474.

Otahel, J. & R. Pazur (2009). Natural landscape potential and land cover/use changes in Slovakia: analysis based on the CORINE land cover data. In: J. Breuste, M. Kozov & M. Finka (eds.): *European Landscapes in Transformation: Challenges for Landscape Ecology and Management, European IALE Conference,* Salzburg (Austria), Bratislava (Slovakia), 74-79.

Otero, I., Boada, M. & Varga D., (2009). Consequences of the transition from a primary to a tertiary landscape in Olzinelles (N.E Spain), 1853-2008. In: J. Breuste, M. Kozov & M. Finka (eds.): *European Landscapes in Transformation: Challenges for Landscape Ecology and Management, European IALE Conference,* Salzburg (Austria), Bratislava (Slovakia), 80-84.

Otoo, E. A. (2017), Residents' perception of granite outcrops in parts of Winneba Township. Department of Geography Education, University of Education, Winneba, Ghana. (Unpublished research work)

Pauleit S., Breuste J., Qureshi S. & Sauerwein M. (2010), Transformation of rural-urban cultural landscapes in Europe: Integrating approaches from ecological, socio-economic and planning perspectives. *Landscape Online* 20, 1-10. DOI:10.3097/LO.201020

Pazúrová Z., Pouwels R., Ruži˘cková J., Bolliger J., Krokusová J., Ot'ahel J. and Pazúr R. (2018). Effects of Landscape Changes on Species Viability: A Case Study from Northern Slovakia. Sustainability: Researchgate Publication. DOI: 10.3390/su10103602

Pedreira, A. & Pedrosa A., (2009). The diffuse urban growth in the valley of river Sousa: assessing the risks placed by the recent landscape changes. In: J. Breuste, M. Kozov & M. Finka (eds.): *European Landscapes in Transformation: Challenges for Landscape Ecology and Management, European IALE Conference,* Salzburg (Austria), Bratislava (Slovakia), 85-90.

Peprah-Asante, G., (2009). Investigating the feasibility of instituting payment for environmental services (PES) scheme in Ghana: The Weija watershed case study. Master thesis. University of Twente, The Nertherlands.

Petley D.N, Hearn G.J, Hart. A (2005). *Towards the development of a landslide risk assessment for rural roads in Nepal.* In: Glade T, Anderson M, Crozier MJ (Eds) Landslide hazard and risk, Wiley, Chichester, 597–620.

Pike, J.G. (1968) *Malawi; A Political and Economic History*, London, Pall Mall Press.

Pileri, P., Siedentop, S., Maggi, M. & Fina S., (2009), Strategies to reduce land consumption: a comparison between Italian and German city regions. In: J. Breuste, M. Kozov & M. Finka (eds.): *European Landscapes in Transformation: Challenges for Landscape Ecology and Management, European IALE Conference*, Salzburg (Austria), Bratislava (Slovakia), 91-94.

Plieninger, T. & Bieling, C. (Eds.) (2012), Connecting cultural landscapes to resilience: In Resilience and the Cultural Landscape: Understanding and Managing Change in Human-shaped Environments; Cambridge University Press: New York, NY, USA; pp. 3–26, ISBN 978-1-107-02078-8.

Popescu, M.E. and Sasahara, K. (2009). *Engineering measures for landslide disaster mitigation. In Sassa & Canuti, P. (Eds) landslides – disaster risk reduction, Springer –* Verlag Berlin Heidelberg.

Potter, C. & Lobley, M. (1996) Processes of Countryside Change in Britain, *Countryside 1990 Series, Vol. 7* (London, Department of the Environment).

Restrepo C., Walker L. R., Shiels A. B., Bussmann R., Claessens L., Fisch S., Lozano P., Negi G., Paolini L., Poveda G., Scharrón C. R., Richter M., and Velázquez E (2009). Land sliding and Its Multi-scale Influence on Mountain scapes. American Institute of Biological Sciences. Bioscience 59: 685–698. ISSN 0006-3568.

Ringrose, S; Vandaerpat, C. & Maheson W. (1997). Use of image processing and GIS technique to determine the extent and possible causes of land management/fence line induced degradation problems in the Okavango area, Northern Botswana. *International Journal of Remote Sensing*, (1997), 18, 11, 2337-2364.

Robbins, P., 2004: Political Ecology. Blackwell, 242 pp

Scharpe, S. C. F., (1938) *Landslides and related phenomena: a study of mass movement of soil and rock.* Colombia University Press, New York, 137p.

Schetke, S., Haase, D., and Kotter T., (2012). Towards sustainable settlement growth: A new multi-criteria assessment for implementing environmental target s into strategic urban planning. *Environmental impact assessment review 32*:195-210

Schumm S.A (1979). Geomorphic threshold: the concept and its application, Colorado State University.

Schuster, R and Highland, L.M. (2001). *Socio economic and environmental impacts of landslides in the western hemisphere*. US geological survey, open file report 01-0276 [online] available: http://pubs.usgs.gov/of/2001/ofr-01-0276/ accessed on 17/06/2018.

Selby, M. G, (1993). *Hill slope materials and processes*, Oxford University Press, New York.

Sidle, R. C., Pearce, A. J and O'Loughlin, C. L. (1985) *Hillslope stability and landuse*. American geophysical union, Washington D.C, USA, 125pp.

Smith, K. (1996) *Environmental Hazards; Assessing Risk and Reducing Disaster*, London, Routledge.

Soeters, R. & Van-Westen, C.J. (n.d), Slope Instability Recognition, Analysis, and Zonation. *Landslides: Investigation and Mitigation*

Solecka, I., Raszka, B. & Krajewski, P. (2018), Landscape analysis for sustainable land use policy: A case study in the municipality of Popielów, Poland. Land Use Policy, 75, 116–126.

Spiker, E. C and Gori P. L (2000). *National landslide Hazards Mitigation Strategy: A Framework for Loss Reduction*: USGS Open-File R

Suleiman, Y.M., Saidu, S., Abdulrazaq, S.A., Hassan, A.B., Abubakar, A.N. (2014). The dynamics of landuse land cover change: using geospatial techniques to promote sustainable urban development in Ilorin Metropolis, Nigeria. AREES. 2014; 1:8–15.

Summerfield, M.A (1991), Global Geomorphology, Pearson Education Ltd, ISBN 0-582-30156-4

Sykes, L. R. (1978) "*Intra-plate Seismicity, reactivation of pre-existing zones of weakness, alkaline magnetism, and other tectonism postdating continental fragmentation*", *Review of Geophysics and Space Physics* Vol. 16 No.4 , pp.621-88.

Turner T. (1998), *Landscape planning and environmental impact design* 2nd edition 1998

Turner, B.L., Moss, R.H., Skole, D.L (2016). Relating Land Use and Global Land-Cover Change in Stockholm, Sweden: International Geosphere-Biosphere Programme (Report 24)

United Nations Environment Programme (UNEP) (2014). Sand, Rarer Than One Thinks. Available online: http://www.unep.org/pdf/UNEP_GEAS_March_2014.pdf (accessed on 24 May 2018).

Van der Sluis, T., Kristensen, S.B.P., Frederiksen, P., Cosor, G., Vădineanu, A., Pavlis, E., Terkenli, T.S., Gaube, V., Vesterager, J.P., (2012). Landscape change processes in case study areas (WP2), VOLANTE Project reports. Deliverable no: 2.3. http://volanteproject.eu/images/stories/DELIVERABLES/VOLANTE_D2.3_Landscape_change_processes_in_case_study_areas.pdf. ALTERRA, Wageningen, p. 87.

Varnes, D. J. (1978). *Slope movement types and processes: In: Landslide Analysis and Control: In Schuster, R. L., Krizak, eds. Transportation Research Board Special Report No.176*, National Academy of Sciences, Washington, D.C P. 11-33.

Vogt Bahati J., Unruh J., Green G., Banana A., Gombya-Ssembajjwe W., and Sweeney S.N., (2006). Integrating Remote Sensing data and rapid appraisals for land-cover change analysis in Uganda. Land Degradation & Development, Vol.17, pp. 31-43. 2006.

Washington State Department of Transportation (WSDOT), (2014): Rail Division. smelsed@wsdot.wa.gov

Westerberg L. O and Carl Christiansson C., (1999). Highlands in East Africa: Unstable Slopes, Unstable Environments? Research for Mountain Area Development: Africa and Asia Vol. 28, No. 5, (Aug., 1999), pp. 419-429 Ambio, Allen Press on behalf of Royal Swedish Academy of Sciences http://www.jstor.org/stable/4314924 (Accessed: 02/12/2018)

Wiens, J.A. 2005: *Toward a unified landscape ecology*: Issues and perspectives in landscape ecology. Cambridge University Press, Cambridge: 365–373.

Wisner, B. (2001). *Risk and the neo-liberal state: why post-mitch lessons didn't reduce El Salvador's Earthquake losses. Disaster* 25(3): 251-268.

Wondimu, A. & Alfakih, E. (2001). Approach for sustainable urban storm water management in the context of developing countries. Proceedings, Novatech 2001, 25–27 June, Villeurbanne

Xiao, D., Zhao, Y., Sun, Z., Zhang, H., (1990). Study on the variation of landscape pattern in the west suburbs of Shenyang. Chinese Journal of Applied Ecology, 1: 75-84 (in Chinese).

Yang, X. (2001). *Change detection based on Remote Sensing Information Model and its application on coastal line of Yellow River Delta.* Earth observation Research Center, NASDA 1-9-9 Roppongi, Minatoku, Tokyo, 106-0032, China.

Yeboah F., Awotwi A., Forkuo E.K., & Kumi M., (2017). Assessing the land use and land cover changes due to urban growth in Accra, Ghana. Journal of Basic and Applied Research International 22(2): 43-50

Zewdie, W, Elmar, C. (2015). Remote sensing based multi-temporal land cover classification and change detection in north-western Ethiopia. Eur J Remote Sens. 2015; 48:121–139.

APPENDIX 1

Accuracy Assessment of Classified Images

ACCURACY ASSESSMENT FOR 1986 CLASSIFICATION

Class Name	Reference Total	Classified Total	Number correct	Producers Accuracy	Users Accuracy
Water Body	10	10	10	100.00%	100.00%
Vegetation	15	10	8	66.67%	80.00%
Urban Area	8	10	6	50.00%	60.00%
Bare Land	7	10	7	100.00%	70.00%
Totals	40	40	31		
Overall Classification Accuracy =	**77.50%**				

ACCURACY ASSESSMENT FOR 2003 CLASSIFICATION

Class Name	Reference Total	Classified Total	Number correct	Producers Accuracy	Users Accuracy
Water Body	10	10	10	100.00%	100.00%
Vegetation	20	10	10	50.00%	100.00%
Urban Area	4	10	4	100.00%	40.00%
Bare Land	6	10	6	100.00%	60.00%
Totals	40	40	30		
Overall Classification Accuracy =	**75.00%**				

ACCURACY ASSESSMENT FOR 2018 CLASSIFICATION

Class Name	Reference Total	Classified Total	Number correct	Producers Accuracy	Users Accuracy
Water Body	10	11	10	100.00%	90.91%
Vegetation	10	3	3	30.00%	100.00%
Urban Area	10	16	10	100.00%	62.50%
Bare Land	10	10	10	100.00%	100.00%
Totals	40	40	33		
Overall Classification Accuracy =	**82.50%**				

APPENDIX 2

UNIVERSITY OF EDUCATION – WINNEBA

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF GEOGRAPHY

GUIDE FOR FOCUS GROUP DISCUSSION

Dear resident,

My name is **Ezekiel Addison Otoo**, a final year MPhil student of geography Education from the University of Education, Winneba. I am carrying out a research to assess the landscape dynamics and related geo-hazards in the Ga South Municipality. The purpose of this interview is to ascertain the extent of landscape change, the causes, its implications and possible future disasters which could be associated with the area. As a resident of this area, your views and ideas are considered very important in this study. I will therefore be very grateful if you could spend few minutes of your time to respond to questions on this study. The information you provide is purely for academic purpose and will be treated with utmost confidentiality.

Do you willingly agree to participate in this study? YES ☐ NO ☐

DEMOGRAPHICS

1. **Age of respondent.** 20 - 25 ☐ 26 -30 ☐ 31 - 39 ☐ 40 - 49 ☐ 50 and above ☐
2. **Sex:** Male ☐ Female ☐
3. **Marital status:** Never married ☐ married ☐ Divorced ☐ Separated ☐ ☐Widow ☐habiting
4. **Educational attainment:** (**Not to be asked directly**)

No formal education ☐ Basic ☐ Secondary ☐ Technical/Vocational ☐

Tertiary ☐

5. **How long have you lived in this area?**

6. **What is your occupation?**

KNOWLEDGE AND EXTEND OF LANDSCAPE CHANGE

7. How was the nature of the landscape when you first settled here?

8. Can you describe the present state of the landscape?

9. Are those changes natural or as a result of human activities?

10. Have you witnessed any landscape change in at least the last ten years in your area?

CAUSES OF CHANGING LANDSCAPE

11. What do you think is the causes of landscape change in this area?

IMPLICATION OF CHANGING LANDSCAPE AND RELATED GEO-HAZARD

12. In your opinion, how has the changing landscape affected you?

13. Have you been affected by slope instability in this area before?

    If yes, how were you affected?

14. Are you afraid of the actions of slope instability? Why?

15. Do you consider your household to be prone to the effects of slope instability?

    If yes how?

16. Would you want to move to stay at a different place?

If yes, why haven’t you moved yet?

If No, why wouldn’t you move?

17. Have you ever seen or experienced any slope instability related geo-hazard or seen an area that has been hit by such geo-hazard before?

    If yes can you describe your experience? When?

18. Did you ever envisage any possible geo-hazard in the area?

19. What do you find to be the effects of slope instability in your area?

20. What disaster/effect do you envisage in the future as a result of the changing landscape?

Thank you for your time!!!

APPENDIX 3

UNIVERSITY OF EDUCATION – WINNEBA

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF GEOGRAPHY EDUCATION

INTERVIEW GUIDE FOR OFFICIALS

(EPA, GSMA, GMeT, GGSA)

Dear Sir/Madam,

My name is **Ezekiel Addison Otoo**, a final year MPhil student of geography Education from the University of Education, Winneba. I am carrying out a research to assess the landscape dynamics and slope instability related geo-hazards in the Ga South Municipality. The purpose of this interview is to ascertain the extent of landscape change, the causes, its implications and possible future disasters which could be associated with the area. As a professional in your field of work, your views and ideas are considered very important in this study. I will therefore be very grateful if you could spend few minutes of your time to respond to questions on this study. The information you provide is purely for academic purpose and will be treated with utmost confidentiality.

Do you willingly agree to participate in this study? YES ☐ NO ☐

DEMOGRAPHICS

Sex

Age

1. What is your profession /occupation?

2. What is your position associated with your profession?

3. How long have you held this position?

KNOWLEDGE AND EXTEND OF CHANGE LANDSCAPE

4. How long have you known this area in your job position?

5. From your profession's point of view, what will you say about the changing landscape in the municipality? Can you explain?

CAUSES OF CHANGING LANDSCAPE

6. What do you think are the factors responsible for the changing landscape in the municipality?

IMPLICATION OF THE CHANGING LANDSCAPE AND RELATED GEO-HAZARD

7. Have there been any report to your office/agency of any geo-hazard in the municipality. If yes can you brief me on any these reports?

8. In what way does your profession relate to the changing landscape?

9. From your professional point of view, how do you envisage the area in the next twenty years in relation to the changing landscape?

Thank you for your time!!!