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A THESIS REPORT ENTITLED

Land Use Land Cover Change and Environmental Implications of Quarrying on Buoho Township and Surrounding Communities – A Remote Sensing Approach

BY

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DECLARATION

I, Stephen Bannerman hereby declare that this submission is my own work towards MSc. Environmental Resources Management and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the university, except where due acknowledgement has been made in the text.

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DEDICATION

To My Dad, late Mum and three elder brothers

Thanks for your support!

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DISCLAIMER

This document describes work undertaken as part of a programme of study at the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi – Department of Materials and Metallurgical Engineering. All views and opinions expressed therein remain the sole responsibility of the author, and do not necessarily represent those of the institute.

ABSTRACT

Rapid expansion of quarrying activities within Buoho Township and its surrounding communities has generated enormous socio-economic development at the expense of damage to biodiversity needed to create a balanced environment. The ensuing noise levels generated from blasting and other quarrying activities cause great discomfort and environmental hazard to the exposed population. This study sought to assess Land Use Land Cover Change (LULCC) that has occurred on Buoho Township and its surrounding communities and subsequent observation of noise related impacts from blasting and other quarrying activities on residents within the exposed communities. Land Change Modeler (LCM) technique was used to carry out LULCC detection of three multi-temporal Landsat images of the years, 1986, 2003 and 2014. This enabled changes that have occurred within a 28 year period to be assessed. Field observations of blast and ambient noise levels at distant locations were also measured. The results revealed a distinct change in bare land and urban space of an annual rate of change of 84% and 44% respectively. Rock outcrop increased steadily at a rate of 2% however, both forest and pasture space were converted to bare land, rock outcrop and urban space showing a decline of 3% rate of change within the period under study. Results from field exploratory blast measurements indicated a decline in noise levels as distance increased from the blast generating point. The highest and lowest blast noise levels recorded were 121.2 dBA and 92.4 dBA at distances of 203m and 1340 m respectively. Social survey results within the study area showed 17% of respondents always experienced noise related effects, while 50% rarely experienced these conditions. Correlation coefficient between the field exploratory blast observations and social survey responses on noise related effects was found to be 0.82, indicating a strong relationship between blast noise levels and it impact on residents within the study area.

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LIST OF ABBREVIATIONS

AKDA	Afigya Kwabre District Assembly
AKDHD	Afigya Kwabre District Health Directorate
ANFO	Ammonium Nitrate Fuel Oil
AOI	Area of Interest
DN	Digital Number
EPA	Environmental Protection Agency
ETM	Enhanced Thematic Mapper
ERDAS	Earth Resources Data Analysis System
ESRI	Environmental Science Research Institute
EROS	Earth Resources Observation and Science Centre
GIS	Geographical Information System
GPS	Global Position System
GSS	Ghana Statistical Service
HDGECP	Human Dimensions of Global Environmental Change Programme
HES	Histogram Equalized Stretch
HTC	High Technology Computers
IEH–MRC	Institute for Environmental Health–Medical Research Council
IGBP	International Geosphere-Biosphere Programme
KMA	Kumasi Metropolitan Assembly
LCM	Land Change Modeler
LULC	Land Use Land Cover
LULCC	Land Use Land Cover Change
MLA	Maximum Likelihood Algorithm
MOFA	Ministry of Food and Agriculture

MSAVI	Modified Soil-Adjusted Vegetation Index
MSS	Multispectral Scanner
NDVI	Normalized Difference Vegetation Index
NIHL	Noise Induced Hearing Loss
NNR	Nearest Neighbour Resampling
OLI	Operational Land Imager
OS	Observation Site
OSHA	Occupational Health and Safety Administration
Para-ML	Parallelepipeds Maximum Likelihood
RGB	Red Green Blue
TIRS	Thermal Infrared Sensor
TM	Thematic Mapper
URT	Upper Respiratory Tract
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
WGS	World Geographic System
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Background

In Ghana, issues of land and environmental degradation has been of great concern since the early decades of the twentieth century. The continuous exploitation of Ghana's rich natural resources has contributed to serious loss of ecological integrity and compromised the ability of the ecosystem to sustainably support life of many local communities, which directly depend on these resources for their livelihoods. Some of the major threats to biodiversity emanate largely from land use transformation, habitat loss, overexploitation, pollution, invasive alien species and population growth. Changes in land cover are inherently dynamic and spatial, and could impact the natural environment in a way that could only be paralleled to climate change (Foody, 2002).

In recent years, Land Use Land Cover Change (LULCC) analysis has become a vital component for managing natural resources and monitoring environmental variations. Information on the nature, extent, spatial distribution, potentials and limitations of natural resources are major criteria, needed to achieve the goals of sustainable development. Nonetheless, rapid growth of urban areas cause governments to face challenges of keeping information about these areas up to date, in order to make well-informed planning decisions (Rao, 2000). LULCC information is significant for many planning and management activities concerned with the earth's surface. It constitutes key environmental information for many scientific resource management, policy purposes and a wide range of human activities (Lillesand and Kiefer, 1994). These information are significant in assessing a range of themes and issues central to the study of global environmental change. Satellite observations usually deliver reliable data on the extent of human exploitation of the earth's landscape in environments, where there is rapid and often unrecorded land use change. This has subsequently enabled earth sensing satellite data to become vital assets in mapping the earth's features, managing natural resources and studying environmental change over the past years.

The expensive and time consuming nature of using traditional method of surveying and other mapping techniques to assess the constant growing urban areas, has resulted in a number of research interests on how to map and evaluate LULCC and environmental implications, using Geographic Information System (GIS) and remote sensing techniques. Also, remotely sensed images are cost effective and are increasingly used as input to analyze these ensuing environmental challenges, whereas GIS technique is used to extract impervious built-up areas and land use land cover from the satellite images (Weijers, 2012).

In recent years, expansion of Ghana's developmental projects such as roads, schools and hospitals has given rise to the establishment of many quarrying companies to meet this growing demand. Many of these companies undertake intensive explorations across the country in search of viable rock outcrops for production. Communities endowed with these resources thus become a haven for the influx of several quarrying companies. The direct or indirect effects of this occurrence results in changes in the land cover of the region by consuming open spaces and agricultural lands. In spite of this concern, ability to make efficient use of land greatly influences the economic and environmental quality of life in society (Turkstra, 1996).

Additionally, Ghana has experienced exponential population growth over the years, which has resulted in the quest for better living conditions in and around the city environment. The upsurge of urban population in almost all major cities and towns across the country and the consequent strain on existing systems has resulted in environmental chaos such as congestion and burden on the limited civic cycle amenities. This situation forces middle class and property developers to move to remote suburbs of the region, therefore the demand for housing and industrial projects within these outlying areas surges exponentially with time thus causes increase in demand for raw materials from quarrying companies to construct new built up areas to meet this occurrence (Vinay, 2000).

Consequently, it is important to recognise the immense environmental impacts, and understand the management techniques needed to effectively mitigate the negatives and enhance the positives. It must be noted that the quarrying industry makes an important contribution to the economic development of Ghana. However, their operations usually give rise to excessive land cover changes and environmental concerns, which require mitigation and control through a well plan system. In view of these challenges, quarrying companies are usually faced with the management of several environmental impacts such as noise generated by the use of heavy duty drilling equipment, blasting, mobile earth moving machinery, processing plant and haulage trucks (Vardhan *et al*, 2006). The reliance on such machinery and blasting activities generate different types and levels of noise, which ultimately affect the ambient noise of the immediate environs.

Even though, rise in modern technology and scientific methods has made it possible for significant amount of environmental impacts associated with quarrying activities to be reduced, there is still a long way to go in order to manage its impact to acceptable levels that will pose minimal danger to the environment. Changes in geomorphology and visual scenery coupled with incessant noise generation from blasting activities are some examples of the significant environmental impacts. Residents living in the operational areas of the various quarrying companies are usually exposed directly or indirectly to these environmental impacts (Smith and Collins, 2001).

1.2 Problem Statement

Buoho Township is endowed with vast rock formations and stone hills, making it an ideal hub for stone quarrying operations. In view of its geology, there has been an emergence of several quarrying companies and activities within the township and surrounding communities in recent years. Raw materials from stone quarrying sites are patronized by customers within Ashanti region and beyond for various construction activities.

Furthermore, the township is rapidly urbanizing and its accelerated sprawl is gradually leading towards conversion of forest lands into larger artificial environment. The migration of many settlers from the conventional central business district within the region to Buoho Township and its surrounding communities has put enormous pressure on land space coupled with rise in population. The upsurge in demand for land space for constructing residential or commercial facilities has made land acquisition, sole prerogative of the highest bidder. In many cases, land close to quarrying sites are a seriously encroached upon by desperate land seekers at the expense of environmental protection. Likewise, some of the quarrying companies also operate in areas close to existing human settlements posing serious environmental and health risk to the exposed communities.

The presence and activities of these quarrying companies gravely impact on the land cover and livelihood of residents in the various communities. One of the most obvious environmental impact in the study area is noise, generated largely from blasting activities. Blast noise impact is usually dependent on the source, topography, land use, land cover of the immediate site and climate conditions (Langer, 2001). The incessant blasting activities and exposure of residents to these noises poses serious noise related health risk. In view of these dynamics, this study attempts to explore and demonstrate the application of remote sensing technique as a useful tool to detect LULCC and evaluate noise level impact from quarrying operations and other activities within the catchment area, using Buoho Township and its environs as a case study.

1.3 Research Objectives

1.3.1 Main Objective

The main objective of this study is to examine LULCC patterns using multi-temporal Landsat images from the past 28 years (1986 – 2014) in Buoho Township and surrounding communities, its role in the expansion of quarrying activities and subsequent noise impact on the immediate environs.

1.3.2 Specific Objectives

a. To map and identify the nature of LULCC from 1986 to 2014.

b. To detect and monitor the extent and rate of LULCC using Land Change Modeler (LCM) technique.

c. To measure noise levels from quarrying activities and evaluate its implications on the study area.

1.4 Research Questions

The research questions resulting from the objectives include:

a. What is the nature of LULCC that has taken place from 1986, 2003 and 2014 in the study area?

b. What is the extent and rate of LULCC that has taken place within the 28 year period of this study?

c. What is the level of blast noise exposure and its health implications on the study area?

1.5 Thesis Organization

This thesis is structured into five chapters. The first chapter gives a background to the thesis, problem statement, objectives and organization of the thesis report. The second chapter covers literature review of previous research carried out in the field of LULCC, GIS and remote sensing techniques, ambient and blast noise, and evaluation of environmental impact from quarrying activities. Chapter three gives a comprehensive account of the study area, materials and method used for this research. The results obtained from the various methodologies used, are discussed in chapter four. Finally, chapter five concludes the thesis with some recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 Concept of Land Use Land Cover Change

Land Use and Land Cover (LULC) are two subjects that have triggered a number of research activities and resulted in a wealth of different approaches to detect past change and also to predict future development (Opeyemi, 2006). Among the most prominent methods are those that use remote sensing and image analysis combined with various statistical and analytical procedures (Arsanjani, 2011).

LULCC identifies all kinds of human alterations of the surface of the earth. Land cover refers to the physical and natural space over the earth surface, including vegetation, water, bare soil and artificial structures (Ellis and Pontius, 2006). Arsanjani, (2011) also considers land use as a complicated expression with different views compared with the term land cover. As such, land managers and social researchers characterize this term generally to include social and economic purposes, while natural science researchers classify the term as different aspects of human activities on land such as farming, forestry and man-made constructions (Ellis and Pontius, 2006).

The study of LULCC through the use of satellite observation has been a major focus of interest to several researchers', right from the early days of aerial photography. However, it has gained momentum with the availability of recent remote sensing techniques that use aircraft and satellites as platforms with the capacity to operate outside the visible part of the electromagnetic spectrum through thermal radiation (Reddy, 2008). For instance, as Ghana strives to attain the status of a developed country in future; expertise in LULCC analysis is needed to curb the emerging problems of chaotic and unregulated development, deteriorating environmental quality, loss of wetlands, fisheries and wildlife habitats. In addition, LULCC data help researchers to assess and understand various environmental practices and problems in order to successfully improve current levels of environment quality (Ikusemoran, 2009). Therefore, this study seeks to use LULCC data to carefully assess changes in land cover of Buoho Township and surrounding communities, which has been caused by quarrying and other human related activities over a 28 year period. Also, the impact of noise generated by the quarrying activities would also be observed to determine the level of blast and other quarry generated noise on the exposed population.

2.1.1 Dynamics of Land Use Land Cover Change

The environment of Ghana is rapidly changing, with land usage and climate change as the most dynamic components contributing to this trend. These components pose serious challenges to nature conservation and management of endangered zones within the country. Hence, dealing with these challenges require efficient monitoring and management of the environment, backed by expert observation strategies (Manakos and Braun, 2014). There are several driving forces which trigger the extent of change in land cover to meet demands for human sustenance and developmental needs. Meyer and Turner II, (1992) characterized some of the main driving forces of LULCC as socio economic organization, technological capacity, level of development and culture.

Quarrying is a major contributing factor to LULCC, though its importance to the economy of a country cannot to be underestimated. Its role in economic development is crucial in terms of production, employment creation and foreign exchange generation (De Vera, 1996). Tujan and Guzman, (1998) also appraised the economic contributions of mining industry but in contrast to De Vera, (1996); they made a tough critique. Tujan and Guzman, (1998) asserted that similar to other sectors of the economy, mining or quarrying firms are usually co-owned by few wealthy local and foreign investors operated on a small or large scale. Therefore, majority of equipment needed to run the sector are import reliant and the mined commodities also usually export oriented, thus pushing the country into regression and plunder by foreign establishments. In addition, activities of these mining corporations gravely impact on the land cover causing depletion and loss of its aesthetic nature.

Land degradation caused by quarrying activities in Ghana, is an enormous environmental challenge that has blighted the country for decades (Akabzaa and Dramani, 2001). The desire for short term gains, drive people in affected areas to overexploit available lands because of poverty. Some examples of these overexploitations include irrigated agricultural practices, industrial activities and urban development (Davaasuren, 2001). Most rural and peri-urban communities in Ghana have been gravely affected by the significant consequences of land degradation. Akabzaa and Dramani, (2001), state that surface mining activities causes vast land areas and vegetation to be cleared just to make way for production. For example in Tarkwa and its environs, about 70% of mining and other open mine concessions constitute the total land mass of the area. Furthermore, it is usually estimated at the close of mining that about 40% to 60% landmass would have been exploited by companies, through siting of mine pits, roads, waste dumps, heap leach facilities, mine camps, offices and resettlement area for displaced communities (Akabzaa and Dramani, 2001). These activities start a mean spiral of decline in the health and quality of life of people living in areas in close proximity to quarrying sites.

Furthermore, the upsurge in the demand for industrial and developmental activities, has encouraged a large concentration of the population within urban and peri-urban areas to venture into land acquisition. These factors result in reduction in intensive farming in most productive lands and abandonment of peripheral lands (Ellis and Pontius 2006). Weijers, (2012) notes that population growth is most of the time defined as the primary cause of urban sprawl. Christiansen and Loftsgarden (2011) also consider housing preferences of people and the characteristics of residential areas as major driving factors for urban sprawl. As the city centres get congested with population growth, the peripheral areas with low crime rates and quiet neighbourhoods usually serve as an ideal zone for land seekers and occupants, thus putting enormous pressure on the land space and its use.

2.2 Remote Sensing and Mapping Solutions

In the advent of a rapidly growing global population, acquisition of consistent and reliable data is needed by managers and planners, for effective decision making. The use of factual information plays a pivotal role in several establishments involved in the constant process of decision making for evaluation of different alternatives. For instance, pictures and aerial photography by their nature portray concisely accurate information about spatial locations, sizes and relationships between objects (Campbell and Wynn, 2011).

Remote sensing is referred to as the acquisition of information of an object without necessarily coming into physical contact. Remote sensors gather data through detection of the earth's reflected energy. These sensors are usually on satellites or mounted on aircrafts. The term remote sensing is also limited to objects that reflect irradiated electromagnetic energy excluding electrical, magnetic or gravimetric parameters that measure the force fields between the sensing device and sensed object (Sabins 1978). Campbell and Wynn, (2011) further define remote sensing as using electromagnetic waves in one or more regions of the electromagnetic spectrum through emission or reflection of the earth surface to obtain information about land and water surfaces through acquisition of images from an overhead perspective.

Measurement of the amount of the earth's energy reflected or emitted is executed by sensors onboard the aircrafts or satellite platforms. These measurements are made over a large number of points scattered along a one-dimensional profile on the ground below the sensor platform or a two-dimensional area on either side of the ground route of the platform. The sensors scan the ground below the platform as it moves forward and subsequently build up images of the earth surface (Reddy, 2008).

In the past four decades, availability of remotely sensed images acquired by sensors aboard aircrafts and satellite platforms has enabled easy categorization and precise modifications in LULCC analysis (Franklin and Wulder, 2002). Again, advancement in computer technology have aided the processing of observation made by sensors of satellites into digital formats, quick and relatively easier. The development in GIS and data integration, has greatly enhanced the use of maps in spatial format. Therefore, methods used in remote sensing are gaining importance in land cover classification analysis. Images obtained from remote sensing techniques are processed using various image enhancement methods such as supervised and unsupervised classification methods to derive classified land cover maps (Boyd and Foody, 2011). Other recognized techniques include pre and post-classification change detection methods such as image differencing, vector change analysis, image regression and rationing (Lunetta and Elvidge, 1999, Berberoglu and Akin, 2009).

Additionally, recent improvements in spatial, spectral and temporal resolution has enabled remote sensing technology to provide special advantages on evaluating growth patterns and their fragmentations (Batty and Howes, 2001). Spatial data acquired through remote sensing technology show consistency spanning large areas. Data covering large areas of the earth surface can be assessed with a greater degree of detail in comparison to the conventional, rigorous and time consuming method of acquiring spatial information. Urban planning and management can be improved greatly and understood through the use of remote sensing technology to obtain and subsequently model environmental data. Also, the use of remote sensing technique for mapping solutions have greatly revolutionized the acquisition of spatial data (Longley and Mesev, 2000, Longley *et al.*, 2001). In view of these advantages, remote sensing technology is the effective tool needed to assess the LULCC that has occur within the study area.

2.2.1 Limitations of Remote Sensing Technique

In the last two decades, LULCC has become an irreplaceable observational feature across the globe through the provision of essential platforms for a wide range of scientific and administrative tasks such as land use planning, hydrological and climate modeling (Manakos and Braun, 2014). However, there has been several calls for improvement in accuracy, spatial and thematic contents of LULCC maps by diverse users' of remote sensing technology that are limited by the current available data. Furthermore, issues of consistency and comparability of different LULCC maps need to be enhanced for a better comprehension of their limitations and suitability for other specific applications.

Currently, the use of different methodologies to create LULCC maps such as classification scheme, data sources and algorithms has raised consistency issues, making comparisons difficult (Hansen and Reed 2000, Göhmann *et al*., 2009; Fritz *et al*., 2011). Accessibility of data is also a problem, because applications in real time are mostly only possible on paper. The time needed for ordering and acquiring satellite images is excessively huge. Again, condition of the weather during ground data acquisition can also be a serious limiting factor. For instance, in satellite observation, the presence of huge cloud cover hampers accurate acquisition of ground data resulting in unreliable Landsat images (Soeters and van Westen, 1996). In order to avoid these likely challenges, Landsat images from USGS online platform will be downloaded carefully according to the correct row and path of the study area. Also, atmospheric corrections and georeferencing technique will be employed for this study to enable reduction in cloud clover and enhancement of the accuracy of the Landsat data respectively.

2.2.2 Future Trends

Earth observation methodologies and applications have become vital in LULCC analysis over the last four decades due to huge gains in innovation, development and achievements. There is now the global shift from pure research of remote sensing techniques towards a multi-modal and multi-source data assessment including data harmonization and process automation (Manakos, 2013). New trends include the use of remote sensing technique in agricultural and environmental applications such as LULCC analysis, disaster management and three dimensional mapping geared towards combining observations from different instruments (e.g. optical sensors, Lidars and radars) to produce excellent outcomes (Freeman, 2012).

Moreover, introduction of free and open data policy for sentinel data such as Landsat imageries by the USGS is expected to make availability of remote sensing data easily accessible. Availability of these data at a marginal cost will trigger huge economic benefits leading to the minimization of entry barriers for prospective users. A typical example is the availability of free Landsat archive data by USGS in December 2008 online, which in turn achieved a million downloads as at August 2009 and 12 million by the end of July 2013 (Makanos and Braun, 2014). Therefore, data needed for this study will be accessed directly from the online archive data platform.

2.3 Role of Remote Sensing and GIS Application in LULCC Analysis

Monitoring LULCC is important for assessing land cover types and understanding anthropogenic impact within a specific period. This assessment involves several thematic themes and concerns critical to universal environmental change management. The significant role remote sensing and GIS applications play in LULCC analysis led to the recognition of the International Geosphere-Biosphere Programme (IGBP) and Human Dimensions of Global Environmental Change Programme (HDGECP) to explore the possibility of extensive research into LULCC improvements (Antwi-Agyarkwa, 2014).

Although, remote sensing and GIS technologies were initially created for different purposes, both effectively provide similar information about the earth resources. Additionally, advent of technological advancement in computer hardware and software, has made data integration from both applications easy. This ability allows users to overlay layers of both remote sensing and spatial data for continuous provision of regional aerial observations and extraction of GIS data layers such as roads, buildings and contours (Skidmore, 2002).

The immense role, remote sensing and GIS applications play in LULCC analysis have influenced several researchers to use data and techniques to analyze LULCC in many parts of the world including irrigation management, erosion, landslide and watershed assessment. Foley *et al*., (2005) quantified the global consequences of LULCC, while Forney *et al*., (2001) worked on land use change and effects on water quality and ecosystem health in Lake Tahoe Basin, Nevada, California. Mya, (2010) also analyzed forest cover change process, using remote sensing and GIS as a case study in Sultan Syarif Hasyim Grand Forest Park in Riau Province in Indonesia.

Furthermore, studies using remote sensing and GIS for LULCC detection across Africa have been done by various researchers across the continent. Vittek *et al.*, (2014), monitored Land Cover Change using Landsat MSS/TM Satellite image data over West Africa between 1975 and 1990. In addition, Gebrehiwet (2004) assessed LULCC in the central highlands of Yerer Mountains and its surroundings in Ethiopia and Ademiluyi *et al* (2008) also did an appraisal on LULCC in Nigeria.

In Ghana, studies on LULCC using remote sensing and GIS applications have been done extensively. Kumi-Boateng and Issaka, (2010) evaluated and modeled LULCC, using remote sensing and GIS in Ejisu-Juaben. Braimoh, (2004) also investigated the impact of seasonal migration and LULCC in an area within the Volta Basin of Ghana, and AntwiAgyarkwa, (2013) assessed the effect of LULCC on the Weija dam in Accra. Thus, this study seeks to examine LULCC patterns using multi-temporal Landsat images from the past 28 years (1986 – 2014) in Buoho Township and surrounding communities, its role in the expansion of quarrying activities and subsequent noise impact on the immediate environs.

2.4 Image Interpretation

Producing and interpreting images on a computer monitor or printed sheet have always been a prime concern of researchers. Image interpretation involves examination of raw data and execution of various data rectification and restoration tasks. Afterwards, the rectified data is converted back to images and used in extracting information by visual interpretation or to support digital image classification (Bakker *et al*., 2009).

Image interpretation or analysis is referred to as the act of evaluating remotely sensed images for the purpose of object identification and assessment of their relevance (Reddy, 2008). These remotely sensed images undergo various forms of logical processes to identify, measure, classify and evaluate the relevance of pattern and spatial relationship between physical and cultural objects. Bradley and O'Sullivan, (2011) also explain image interpretation as the use of band ratios constructed from each input image such as NDVI to determine differences between band ratios at different periods. For instance, in determining the differences between NDVI images, positive output values indicate an increase in vegetation, negative values indicate decrease in vegetation, and values near zero indicate no change. This technique enables change detection of remotely sensed images to be assessed over vast land areas. However, the results may not be as accurate or precise in comparison to those directly acquired from field monitoring.

Karl and Axel, (2013) note that using Global Position System (GPS) to obtain vegetation data, may be spatially more precise or accurate than those acquired through satellite imageries, which has their accuracy or precision limited to the resolution of the pixel. Although, there is a possibility of image pixels being compromised when vegetation types are mixed, there would still be problems with the accuracy since DN values for each pixel would remain single.

In addition, data obtained from field observation for LULCC detection enables clear identification of the nature of change between two sample periods. However, there are restrictions with the availability of information when image differencing algorithm is applied at this level, but this can be rectified by classifying each image. Thus, this study seeks to use classification technique to categorize all the pixels in the downloaded images into various land cover classes for effective comparison and identification of LULCC.

2.5 Change Detection

The influences of environmental, social and economic dynamics cause LULCC to occur at varying rates and in different locations. Molders, (2012) states that these changes in rate can be subtle, gradual, intense, or sudden. The activities of quarrying is a typical example of an environmental dynamic that can cause a sudden change in the earth's landscape, while farming and grazing produce gradual changes. Detection of these changes involve the use of manual interpretation or a remote sensing software such as Erdas Imagine, Idrisi Selva or ArcGIS. Manual interpretation of remotely sensed images or aerial photos is done by defining areas of interest and comparing two or more images of different periods by an observer or expert while digital interpretation involves either an on-screen analysis of two or more images of different periods using GIS software or paper print (Karl and Axel, 2013).

Many change detection algorithms have been used over the years to estimate statistical relationships, principles and assumptions of several remote sensing applications for LULCC evaluation (Singh, 1989). These change detection algorithms include image digitizing, overlay, differencing, regression, rationing, vegetation index differencing, post classification comparison and change vector analysis (Singh, 1989, Coppin and Bauer, 1996, Sunar, 1998). There is no such thing as the best change detection approach, since most of these algorithms have been applied successfully for LULCC analysis. The contributing factors include easy data accessibility, topography of study area, calculating restrictions and type of software application (Kebede, 2009).

2.5.1 Manual method

This method of interpretation is employed, when determining changes in images or photos from different sources such as comparison between historic aerial photographs and satellite images. Nonetheless, this traditional method of LULCC detection is time consuming, labour intensive and executed sporadically. In view of these constraints, users have become increasingly reliant on multi-temporal remotely sensed data (Sader and Hayes, 2001).

2.5.2 Automated Method

This method involves the use of satellite images or aerial photographs to detect LULCC through the use of a remote sensing software such as Erdas, ArcGIS or Idrisi Selva. This method of automation is in two forms, namely: post classification change detection and image differencing using ratio bands (Karl and Axel, 2013). Post classification analysis involves comparison between two or more classified images that have been categorized into distinct patterns known as land cover types or classes. In the process of comparing the classified images, areas showing the same or different classifications are tallied to produce the final output map. Unclassified areas and erroneous classifications are subsequently removed. Some approaches that are normally used for change detection are NDVI, MSAVI, supervised and unsupervised classifications.

In comparison to the manual method of change detection, the automated approach offer users huge economic gains due to its capacity to assess huge landmasses of interest such as the study area. Additionally, the availability of remotely sensed data also enable easy review and analysis. Hence, the automated method will be used for all the classification process for this study

2.6 Image Classification

Human vision plays a pivotal role in extracting information and interpretation of images. Notwithstanding the advent of computers for image visualization and digitization, actual interpretation is still done by users. The computer only performs image interpretation under strict supervision and instructions from the user according to specific conditions.

Image classification is one of the techniques used for digital image interpretations. This is based on several spectral characteristics. Other techniques include automatic object recognition (e.g. road detection) and scene reconstruction (e.g. generation of 3D object models) (Bakker *et al*., 2009). Image classification is denoted as the automatic categorization of the entire pixels in an image of a landscape or topography into land cover types or classes (Reddy, 2008). In the process of categorization, pixels are allocated to specific class based on their vector features, through comparison with predefined bands in the feature space (Bakker *et al*., 2009). Image classification techniques are grouped into two types, namely: supervised and unsupervised.

2.6.1 Supervised classification

Supervised classification requires the use of pixels of known reference samples within the area of interest as basis of comparison between pixels of objects within the same setting. The nature and number of classes are created prior to classification by the user however, assignment of pixels to the classes is done by the computer. Spectral characteristics of the sample area are defined based on proximity of points to be classified to each training sample (Reddy, 2008). For this study, supervised classification will be used instead of unsupervised because of familiarity of the study area and collection of GPS points (i.e. 4 points for each land cover class) to enable correct assignment of training samples to each land cover class for efficient classification.

2.6.2 Unsupervised Classification

Unsupervised classification involves examination of a large number of vector data, which are subsequently divided into classes based on their intrinsic properties with no comparison between points to be classified and training data (Reddy, 2008). This type of algorithm is usually applied when the user has little or no information of the area to be classified.

2.7 Accuracy Assessment

Accuracy of remotely sensed images are of great concern to prospective users of LULCC maps. Information about the degree of accuracy of the data presented in a LULCC map is needed to ascertain its authenticity. Accuracy of an image can be defined as the measure of agreement between a standard, acknowledged to be correct and an image of unknown quality. On the other hand, precision of an image is defined as the degree of sharpness or certainty of pixels in an image (Campbell and Wynne, 2011).

Accuracy has many practical implications; for example, it affects the legal standing of maps and reports derived from remotely sensed data. Accuracy cannot be assessed solely by the appearance of a map, since the overall accuracy might be unrelated to the map's cosmetic qualities. However, determination of the accuracy of a map of an area understudy, should be done in a manner that allows quantitative measure and comparisons with alternative maps and images of the same area (Campbell and Wynne, 2011).

Assessing the accuracy of a classified output map involves the use of a sampling approach, in which a number of selected raster elements of the classified output map are compared with data from field observations or Red Blue Green (RGB) composite Landsat image of the area under study using an error matrix. An error matrix is a square collection of numbers defined in rows and columns that represent the number of elements allocated to a specific land cover class, and comparative land feature confirmed on the ground through field observations or data derived from the RGB composite Landsat image. Rows in an error matrix denote LULCC map, while columns denote ground truth data or data from RGB composite Landsat image. The error matrices generated for each period under study enable tables to be formed for statistical measures of thematic accuracy such as overall accuracy, error of omission and commission, kappa coefficient, producers' and users' accuracy (Congalton and Green, 1999).

Error of omission is the percentage of pixels that originally should have been assigned to a particular land cover class but are left out due to oversight or blunders, while error of commission is the percentage of pixels that are wrongfully placed in a different land cover class either than the intended class. These errors can also be expressed in the form of users and producers accuracies. The probability that a specified pixel on a classified map can be correctly matched or identified on the ground is referred to as users' accuracy, while producers' accuracy is expressed as the percentage of specified pixel that can be correctly identified on a classified land cover map.

Additionally, kappa coefficient is a statistical indicator used to test the inter-rater reliability of a data (Cohen, 1960). This rater reliability test is used to determine, whether the degree or amount of data collected for a particular research, are true representation of the variable measured. In LULCC analysis, kappa coefficient is defined as measure of agreement between the model prediction such as classified LULCC map and actual data on the ground whereas, in an error matrix it is used to determine whether the values contained in the matrix represents a result significantly better than that of random values. Kappa coefficient value ranges from – 1 to + 1, where + 1 indicates a perfect agreement between actual field data and a classified map, 0 is a representative of complete randomness or the degree of agreement that is likely to be obtained from a random wager, – 1 indicates a perfect disagreement between the classified map and actual field data (Cohen, 1960). Accuracy assessment is a complex process; nevertheless, its importance to the validation of image classification results cannot be underestimated. The assessment of accuracy enables different measures of errors from the resulting validation process to be calculated.

2.8 Potential Environmental Implications of Dimension Stone Production

The advent of modern technology, has enabled several environmental impacts from quarrying activities to be managed at some acceptable levels. The extent or level of impact on the environment depends on rock characteristics, brand of technology and mining method used in blasting and processing (Benin, 2007). Consequently, the detrimental effects of quarrying on the environment at local, regional and global levels would continue to be a topic of public concern. Some potential environmental impacts of quarrying activities include: noise and vibration, land degradation, habitat loss, air and water pollution.

2.8.1 Noise and Vibration Effects

Quarrying is associated with several activities that generate huge amount of noise levels, from preliminary through to the closing stages. Some of the activities that take place at the preliminary stage include clearing of trees, construction of roads or rail routes and installation of processing plant. Afterwards, topsoil or overburden is removed by excavation to expose the rock mineral for commencement of production. The exposed rock is drilled and charged in preparedness for blasting. After blasting, the fragmented rocks are then crushed and milled into various sizes of dimension stone. Finally, the end products are transported to prospective buyers by heavy duty trucks along public roads. All these activities; generate considerable amount of noise into the environment, which poses great health risk to the exposed community.

Over the years, there has been a plethora of complaints lodged by affected individuals to protest against blasting activities from quarrying companies. Some complains often registered by affected individuals include legitimate claims of damage from vibrations and fallen rocks. However, false complains are sometimes made by individuals as a result of damages that may have result from natural setting and poor building construction.

Furthermore, the use of high energy explosives to blast a mineral in order to extract several rubbles for processing, is usually accompanied by adverse seismic effects such as noise, overpressure and ground vibrations (Singh *et al*., 1996). As a result of continuous blasting, the seismic effects often cause individuals living in proximity to quarrying sites, to experience several noise related ailments such as headaches, hearing impairment, stress, sleeping disorders and cardiovascular effects.

2.8.2 Air Quality Effects

The generation of dust from quarry sites into the ambient air is a major reducing factor of air quality. The degree of exposure depends on concentration, size and chemistry of dust particles in the ambient air. The deposition of dust on surfaces is not only detrimental to the ambient air quality but also, on the respiratory health of exposed individuals within the affected community. There is also physical effects on neighbouring plants as a result of damage and blockage to the internal structure, abrasions, cuticles and other chemical effects, which may reduce their long term subsistence. Also, the explosives used in blasting causes other poisonous gases to be emitted into the ambient air aside from dust. Some of the gaseous emissions include Sulphur dioxide (SO_2), Carbon monoxide (CO) and black smoke, which are all harmful to the health of exposed individuals (Bell and Holloway, 2007).

2.8.3 Aesthetics

Quarrying activities create huge cavities or craters on existing land surfaces, which change the quality of scenery. These craters are sometimes filled with rain and ground water, which create huge ponds that alter the original landforms of the affected area. Also, changes to surface water route, erosion and deposition of habitats around quarry sites reduce the aesthetic appeal of the immediate environment and discourages tourism.

2.8.4 Habitat loss

The activities of quarrying, gravely impact on the habitat of faunas within the affected area. Continuous drilling, blasting and fragmentation of rocks destroy passages and caves which serve as habitats for several endangered species. As a result these activities, many of the affected species are forced to migrate to new habitats, where there may be a little chance of survival.

2.8.5 Water Quality.

Quarry operations usually affect surface water run-off and ground water quality through contamination from dissolved and suspended solids. These operations can cause substantial change in the course or route of surface water run-off and deterioration of ground water quality (Gunn and Hobbs, 1999). Additionally, deposition of dust particles on water surfaces from quarry sites, which contain chemically active minerals can change the water quality. A deteriorated water quality, has immense rippling effect on the fauna and flora that it supports (Banez *et al*., 2010). Similarly, large amount of silt and effluents from quarry sites that are discharged into far and nearby river bodies and ground water posing great danger to dependent aquatic organisms and residents (Mate, 1992).

2.9 Environmental Noise

Environmental noise is defined as annoying or harmful outdoor sound generated by human, traffic, industry, construction and recreational activities (Manjala, 2014). Dubbink, (2010) states that assessment of sound intrusion on human activities is more subjective, whereas the dynamics of sound transmission indicates that an emitted sound from a source travels in the air and decrease in level as the distance increases (Nunez, 1998). Increase in distance enables the distribution of acoustic energy over an expanding linear area, subsequently causing decrease in the sound. In addition, factors such as wind, temperature and humidity also influences the transmission of sound between the source and receiver (WHO, 1990).

2.9.1 The Decibel Unit

Decibel (dB) is referred to as the logarithmic unit used to measure the level of intensity or pressure of a sound relative to the inception of human hearing (WHO, 2000). The human ear is extremely sensitive to the slightest noise that is created, from fingertip scratching feebly over once head to a loud horn from a moving train.

The decibel scale rates the smallest audible noise that is near total silence as 10 dB. However, a noise that is generated 10 times more powerful over the total silence is rated by the decibel scale as 20 dB. Similarly, a noise generated 1000 times more powerful is rated 30 dB by the decibel scale. The sound level of a normal conversation can be measured at 65 dB on a decibel scale. However, any exposure of sound above 85 dB can cause hearing loss and immediate pain at 130 dB in terms of the power and length of exposure (Dubbink, 2010).

In terms of pressure, a normal ear can detect the smallest sound pressure at 0.00002 Pa or 20 μPa relative to a sound frequency of 1000 Hz (Howard and Angus, 2001). Dubbink, (2010) notes that at certain intensities and frequencies, the rise and fall in air pressure can generate sound. Hearing ranges from 20 to 2000 cycles per second, which is normally abbreviated as (cps) or Hertz (Hz). Therefore, when the rise and fall in air pressure surpasses 20 cycles per second, individuals begin to hear sounds.

2.9.2 A-Weighted Sound Level

Sound consist of three classes of frequency including low, medium and high. The frequency of a sound is classified as low, when the number of sound waves is below 200 Hz. When it ranges from 200 Hz to 2000, it is classified as Medium. Likewise, if the number of sound wave is above 2000 Hz, it is classified as high (enHealth, 2004). The human ear identifies these classes of frequencies with some amount of sensitivity; hence, A-Weighting is applied to sound level measurements in order to account for the relative intensity perceived by the human ear. For instance, Robert (2002) notes that at the same decibel level, a sound of low frequency may not be heard by the human ear as loud as one with a high frequency. In order to mirror this property, acoustic filters are fitted on sound measuring devices. These acoustic filters (A) sieve out some amount of low frequency sound or noise measured, similar to the reactions of the human ear (Harris, 1997). A-Weighting is usually used for measuring environmental noise including blast, road, rail and aircraft noise and denoted as dB(A) or dBA (Howard and Angus, 2001).

2.10 Health Assessment

Blasting activities normally break rock outcrops into pieces suitable for crushing and haulage. Prior to the commencement of a blasting activity, holes are usually drilled into rock outcrops of viable interest for charging. These holes are successively charged with explosives such as Ammonium Nitrate and Fuel Oil (ANFO) or dynamite and readied for detonation. The detonation is triggered by explosives within shot holes, which cause swift discharge of energy resulting in a tremendous rise in pressure and temperature to break the rocks into several fragments. However, in the course of rock fragmentation, majority of the energy released is wasted as noise, heat, dust, fly rocks, vibration and noxious gases (Nanor, 2011). These fragmented rocks are later transported from pits and hills to the processing plant with bulldozers and haulage trucks for milling into dimension tones.

Over the years, the impact of environmental noise on the health and safety of many individuals has raised a lot of concern. Some of the impacts include both psychological and physiological such as annoyance, hearing loss, sleeplessness, depression, headache and cardiovascular problems (King, 2008). Quarrying activities generate high levels of noise, from blasting, crushing and haulage of finished products by heavy duty trucks (Langer, 2001). These activities generate various forms of noise levels, which poses great danger to workers and residents living in close proximity to quarry sites.

2.10.1 Noise Exposure Assessment

Noise exposure may be identified as a problem in certain environments based on several factors that has been documented, including urban areas with immense industrial and commercial development, high population and vehicle concentration (King, 2008). These urban activities usually generate huge levels of noise, which pose great danger to the exposed community (Passchier-Vermeer and Passchier, 2000). Although, many individuals react differently to noise, particular attention must be paid to other subjective responses, which may provide warnings for detection of other unacceptable noise levels (OSHA, 2015).

In order to tackle the issues of environmental noise exposure, it is advisable to use a qualitative risk assessment approach to estimate the burden of disease on the environment. This involves hazard identification, population exposure assessment and use of appropriate response interactions (WHO, 2011). There are several classes of noise metrics that are available for noise exposure quantification such as the use of maximum A-weighted sound level for sleep studies. However, for effective health studies only a limited set is used based on the amount of energy an individual is exposed to (Swift, 2010).

2.10.2 Noise Related Health Effects

Many individuals exposed to extreme and continuous elevated noise levels are at a risk of experiencing auditory and non-auditory effects. Auditory effects caused by elevated noise levels on individuals are those associated with temporary or permanent hearing loss, while non-auditory effects are those associated with behavior and physiology (ICH – MCR, 1997). Bistrup, (2001) suggests that non_auditory effect occur as a result of greater concentration and listening effort, when living and working in a noisy environment. This in turn can lead to irritation, aggression, depression, headaches and disturbance in sleep patterns (Edwards, 2008). Another long-term non-auditory effect of Noise-Induced Hearing Loss (NIHL) has been shown to be the presence of tinnitus. Tinnitus in many cases cause mood swings, loss of concentration and speech recognition. In some cases, affected persons become extremely annoyed (Axelsson and Prasher, 2000).

Noise is generally acknowledged as an invasion into a person's privacy, particularly in urban environments (Cohen and Weinstein, 1981). Aside from the psychosocial effects from community noise exposure, there is a growing concern about its impact on public health, particularly on the issues associated with cardiovascular effects (Stansfeld *et al*, 2000). These cardiovascular issues may include short term changes in blood circulation involving blood pressure, heart rate, cardiac output and vasoconstriction and hormonal stress (WHO, 2011). Additionally, there can be temporal alterations in the biological responses in an individual as a result of arousal of the autonomic nervous and endocrine system. The inability of certain organisms to fully adapt to the physiological consequences associated with chronic noise stress can affect their homeostasis (Spreng, 2000).

2.10.3 Other Related Health Effects

Aside from noise emission, blasting activities also greatly affect the environmental air quality. Over the years, reported cases and grievances of many affected communities on air quality have been airborne particulate matter, emissions of black smoke and heat after blasting activities (Akabzaa and Darimani, 2001). The discharge of dust, noxious gases and heat after blasting, pollute the ambient air and subsequently pose great danger to residents in close proximity to the quarry sites. Prolonged exposure to these pollutants can cause respiratory disorders, exacerbating conditions of individuals already suffering from asthma, pneumonia, Upper Respiratory Tract (URT) infections and arthritis. These ailments are prevalent in areas, where the quarrying companies do not comply with the standard safety measures for preventing harmful emissions into the ambient air after blasting activities.

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Area

3.1.1 Location and Size

Buoho Township and its surrounding communities as shown in Figure 3.1 and 3.2 is located in Afigya Kwabre District of the Ashanti Region of Ghana between latitude 6°45' N to 6°50' N and longitude 1°38' W to 1°42' W. The district shares boundary with Kumasi Metropolitan Assembly to the south, Sekyere South to the north, Offinso Municipal Assembly to the west and Kwabre District to the east, covering a total surface area of 342.4 km^2 being approximately 1.4 percent of Ashanti regional land surface area (Asante *et al*, 2014). The district lies strategically in the central part of Ashanti region and along the highway which runs from the south to the north of the country making it accessible to most areas, thus it serves us a hub for several commercial activities (AKDA, 2014).

3.1.2 Climate

The district lies within a semi-deciduous forest zone characterized by relatively high rainfall about 1400 mm per annum with a binomial pattern. The major rainfall season occur between March and July with a peak period from May to June. However, there is a minimal rainfall occurring between August and October. The district has a fairly uniform temperature, ranging between 25 °C in July and 28 °C in April. The maximum temperature for the district has been observed to be increasing steadily in recent times throughout the year. Sunshine duration for most part of the year averages seven hours per day. Relative humidity is generally high throughout the year ranging between 90% and 98% during nights and early mornings in the wet season and 50% and 75% during day time in the dry season (AKDA, 2014).

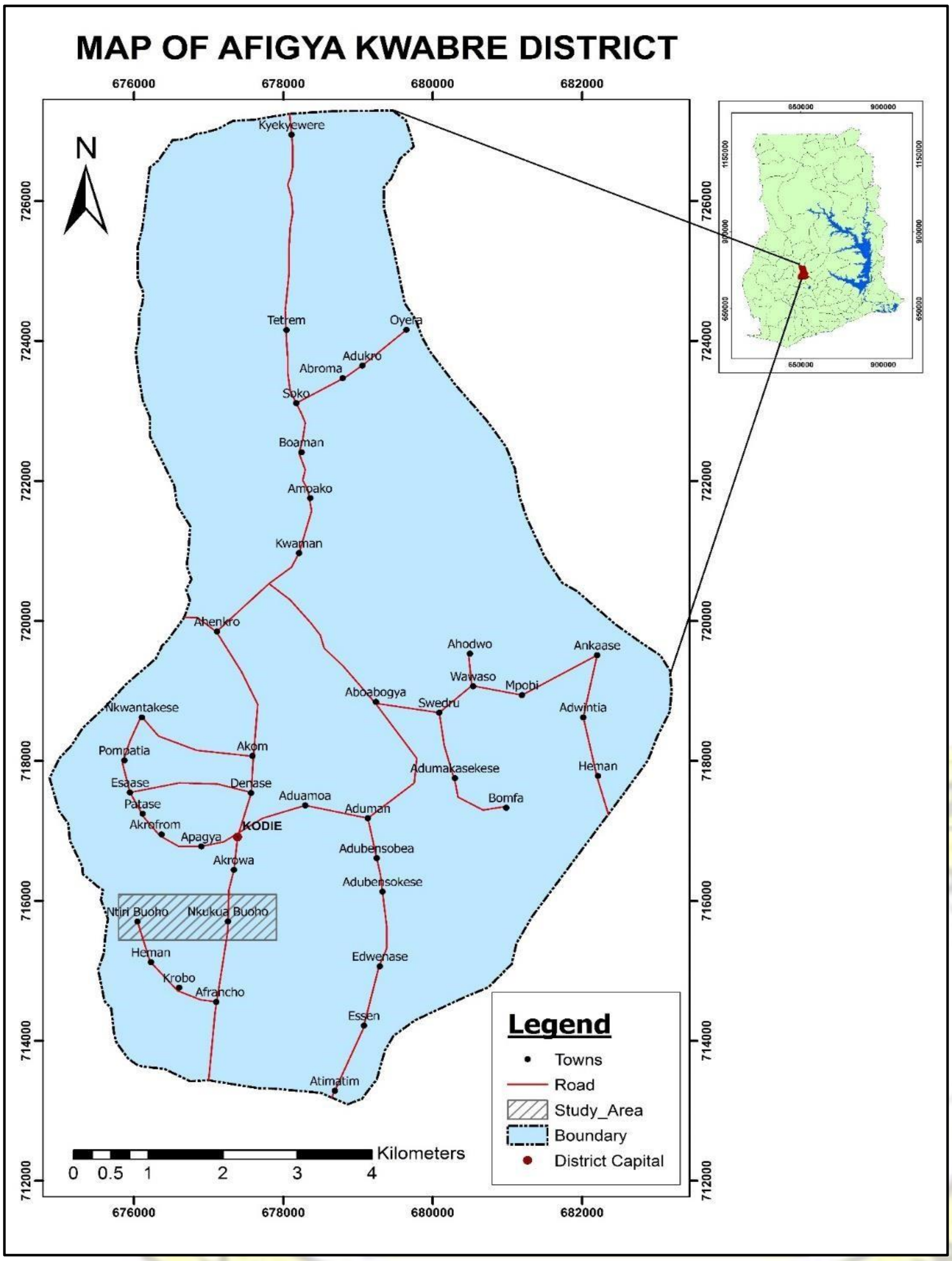

Figure 3.1 Map of Afigya Kwabre District

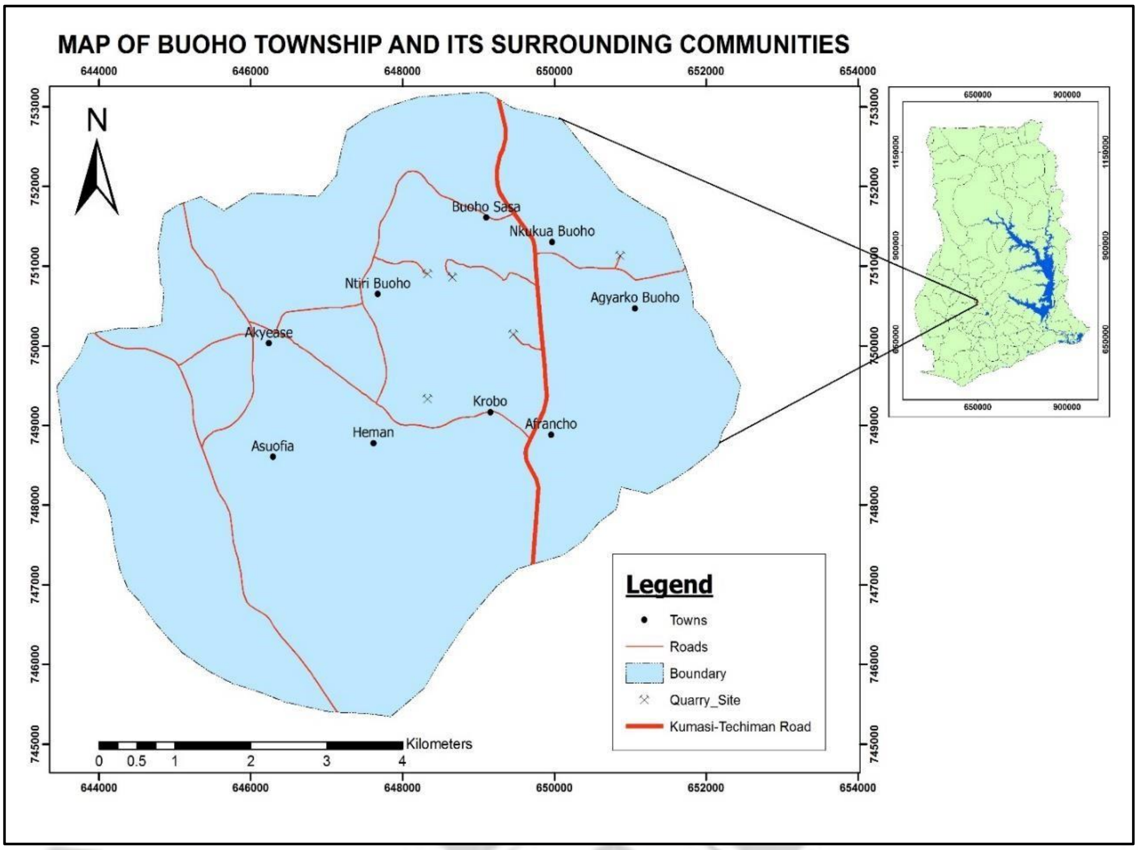

Figure 3.2 Map of Buoho and its surrounding communities.

3.1.3 Topography and Land Use Land Cover

Buoho Township lies within a dichotomized plateau, which forms part of the MampongGambaga scarp with an undulating topography. Geologically, Afigya Kwabre District is made up of two distinct rock formations namely Voltaian and Dahomeyan rocks. The Dahomeyan formation consists of igneous and metamorphic rocks with gneiss and granite being dominant in areas like Nkukua Buoho, Agyarko Buoho, Ntiri Buoho and Adomako Buoho. This has given localities in Buoho, the accolade of being home to most quarrying industries (AKDA, 2014). Vegetation and land cover is mainly forestlands, which has been largely degraded by lumbering, farming, expansion of settlements and quarrying. In recent times, the closed forest consisting of a continuous canopy of tall and medium height trees with little or no undergrowth trees. However, the area is currently characterized by large farm patches with isolated stands of individual trees or small areas of tree clusters

(MOFA, 2014). Some commercial quarry companies in the study area extracting mineral aggregate for sale to construction firms are namely World Cool Quarry, ESM Quarry, KAS Company, CYMAIN Ghana Limited and TAYSEC Construction. Irrespective of the commercial mining by these companies, a chunk of the local population are involved in small scale quarrying. Stone quarrying provides countless opportunities for the people of Buoho in terms of jobs and income generation (Asante *et al*, 2014).

3.2 Materials

3.2.1 Equipment and Software

Summary of field equipment and software programs used for this research are shown below in Table 3.1, Table 3.2 and Figure 3.1.

Table 3.1 Field Equipment

Equipment	Use
OEM Digital Sound Level Meter	Measurement of ambient and blast noise levels
Garmin Handheld GPS	Field navigation and ground truth data collection
Sony Digital Camera	Capturing of photos of study area and blast point locations
Umbrella	Provision of shade from harsh weather conditions
Wooden Pegs	Mark out ambient and blast noise locations
Notepad and Pen	Recording of field data
Cutlass	Clearing of weeds
HTC Android Phone	Measurement of meteorological conditions

Table 3.2 Software programs

Software	**Use**
ArcGIS 10.2	GIS analysis and generation of output maps
ERDAS Imagine 9.3	Image processing and classification and
Idrisi Selva 17.0	Land cover modeler analysis
ILWIS	Selection of optimum band index factor
Microsoft Word 2013	Thesis write-up
Microsoft Excel 2013	Statistical analysis
Microsoft PowerPoint 2013	Thesis presentation
Mendeley	References

Figure 3.3 Digital sound level meter

3.2.2 Landsat Image

Three historical Landsat satellite images covering Buoho Township and its surrounding communities for the past 28 years (1986-2014) were used for this study. These images included Thematic Mapper (TM), Enhanced Thematic Mapper (ETM) and Operational Land Imager/Thermal Infrared Sensor (OLI/TIRS) as remote sensing data acquired. An irregular set of 11 year and 17-year period images of 1986, 2003, 2014 were chosen. This was because of non-availability of images that meet the required cloud cover of less than 10%. These satellite images were acquired through, the Earth Resources Observation and Science Centre (EROS) of United States Geological Survey (USGS).

Table 3.3 Landsat images and reference data used for the study

RS Data	**Reference Year**	**Resolution**	**Date of Acquisition**	**Path/Row**	**Source**
Landsat 5 TM	1986	30m	27-01-1986	194/55	USGS
Landsat 7 ETM	2003	30m	19-02-2003	194/55	USGS
Landsat 8 OLI/TIRS	2014	30m	26-12-2014	194/55	USGS

Reference Data	**Scale**	**Date of Acquisition**	**Source**
Topographical Map	1:50000	1992	Survey Department
Aerial Photograph	1:250000	2003	Survey Department
Google Map	1:80000	2015	Google Earth Online

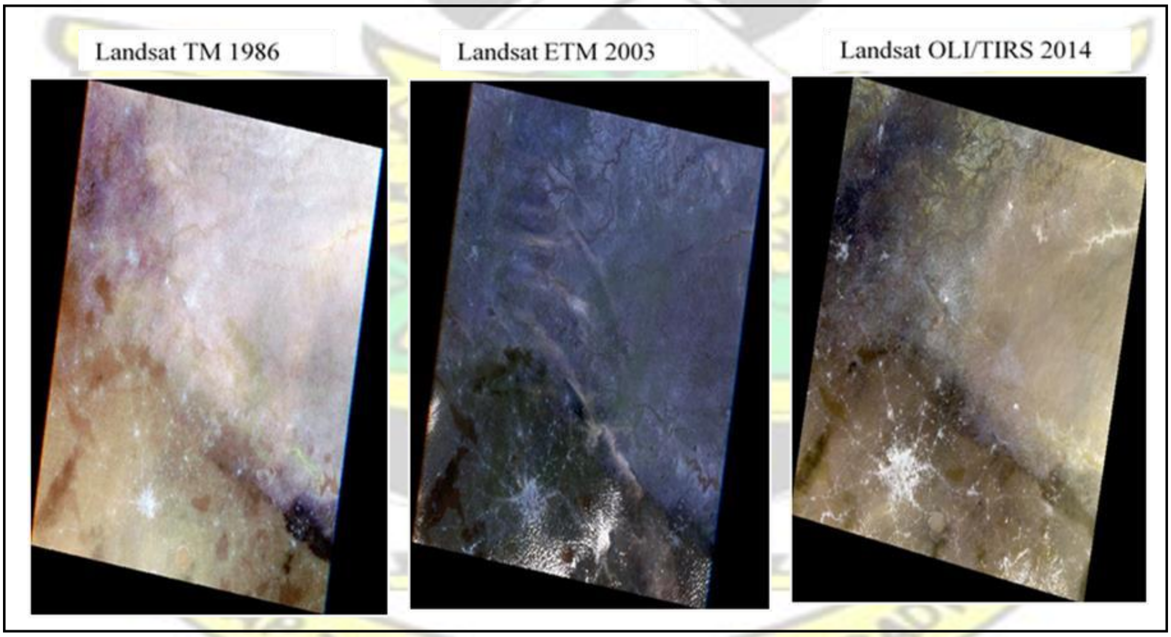

Figure 3.4 RGB composite Landsat imagery used for the study

3.2.3 Reference Data

In this multi-temporal land cover study, it was necessary to use a variety of methods to develop reference data sets for training samples and accuracy assessment. This study relied mainly on high resolution aerial photographs and Google Maps for classification and assessment. Topographical map of the study area acquired from the District Assembly was also used to perform geometric correction of the satellite images. Ground truth data obtained from the field were also used for georeferencing and rectification of images.

3.2.4 Questionnaire

Self-administered multi stage questionnaire as a data collection tool, was used to obtained firsthand information from respondents living within the operational areas of the quarrying companies. The questions asked were mainly centered on potential environmental effects of quarrying blast activities on prospective responders.

3.2.5 Health Data

Out-patient morbidity data from health facilities mostly frequented by residents in the study area and surrounding communities from 2011 to 2014 were acquired from the district health directorate. The health data was acquired to ascertain, the upsurge or emergence of quarrying related diseases in the various communities in the study area. This was essential to ascertain the types of outpatient mobility cases often reported at the various hospitals within the study area.

3.3 Method

This section describes data and methods that were applied in preprocessing, processing, presentation and analysis of data with the aim of achieving the designed objectives and the research questions posed. Figure 3.5 shows a flow chart summarizing the methodologies that were used during the execution of this study.

FLOW CHART OF METHODOLOGY

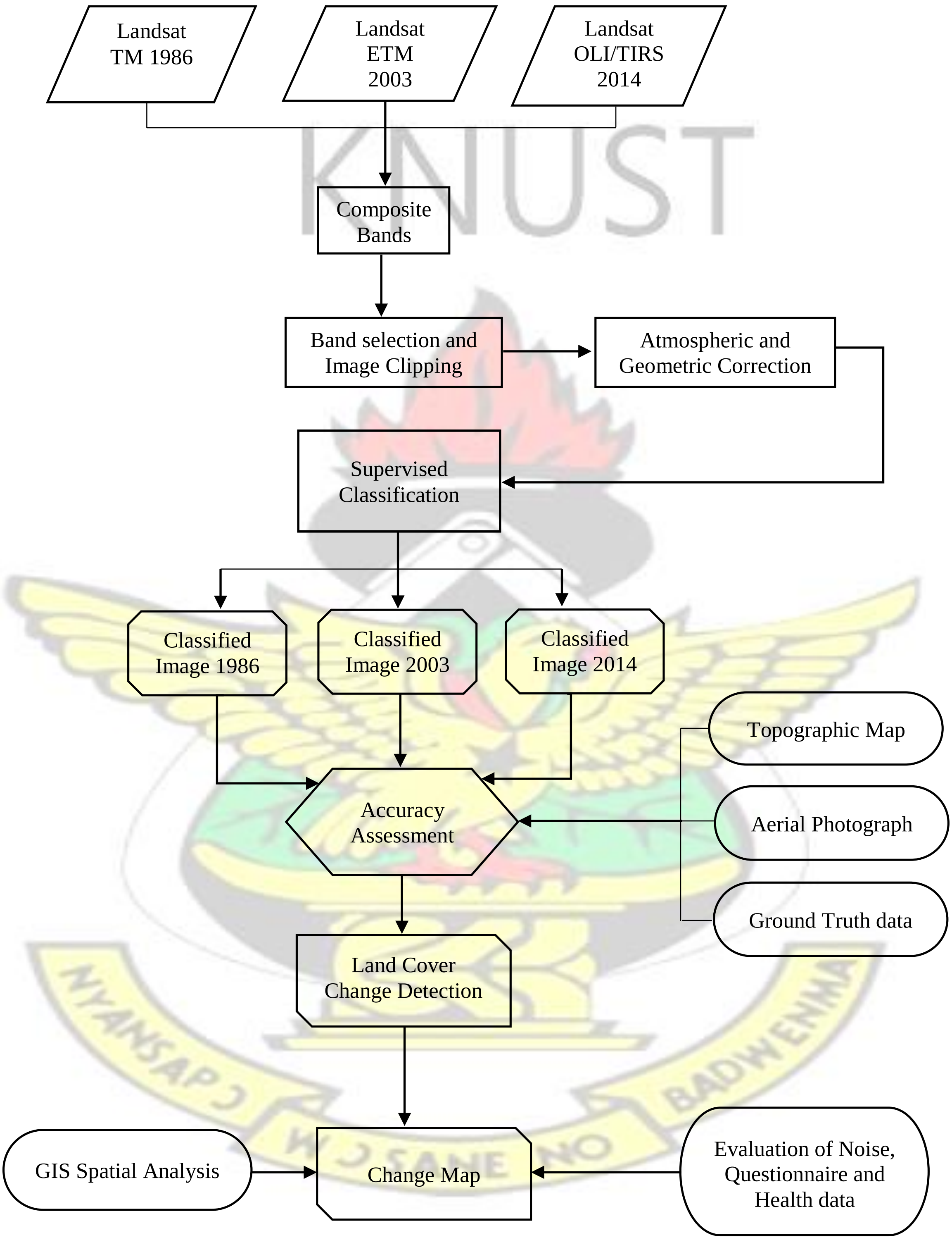

Figure 3.5 Flow chart of research data and methodology

3.3.1 Field Reconnaissance

Field investigations were undertaken in areas of interest under this study to collect terrain information, useful for image interpretation and analysis. Field visits were carried out to test accuracy of image interpretations at selected sites to clarify image interpretation assumptions. Also GPS points taken from the field were also used to locate accurately, ground sites investigated.

Furthermore, suitable locations for exploratory ambient and blast noise levels measurements were marked out using wooden pegs and spatial positions picked using a handheld GPS. The locations were selected based on proximity to quarry company and cluster of houses.

3.3.2 Band Selection

Landsat images downloaded from USGS EROS online database were imported into ArcGIS 10.2 using the composite band spatial analysis tool co-registered under World Geographic System (WGS) 1984 and Universal Transverse Mercator UTM Zone 30 North (N) coordinate system. The resultant Red Green Blue (RGB) composite Landsat imageries were obtained by selecting seven (7) bands from each image for import. Using ILWIS software optimal index factor was used to obtain the best 3 – band combination for this study (Offei and Tagoe, 2015). The natural band combination used for both Landsat images of 1986 and 2003 were bands 5, 4, 2, and 6, 5, 2 was used for the Landsat image of 2014.

The visible band combinations enabled ground features to appear in colours similar to the appearance of the human visual system. Forest vegetation appeared as green, recently cleared forest areas and pastures as light green, rock outcrop as a combination of darker and light brown, bare lands as white and urban/built up areas as purple and mauve. Spatial subset of the image of interest were extracted using the clip tool found under the spatial analyst tool in ArcGIS 10.2. This tool allowed an extraction of a portion of the raster dataset based on a template extent. The clipped area of interest was specified, by using a digitized boundary extent file of the study area. The output clipped images were exported and saved as an Erdas Imagine (*.img) raster dataset format. These raster datasets were saved in the same spatial coordinate system of the study area.

3.3.3 Geometric and Radiometric corrections

The RGB composite Landsat images were imported into Erdas Imagine image processing software using the built-in import dialog. The same coordinate system (i.e. WGS 1984 UTM 30N) was maintained, to prevent image misregistration and referencing error leading to wrong change detection and vice versa. Using the spatial modeler tool in Erdas Imagine 9.3, geometric corrections were performed on the images to correct for errors arising from imaging sensors, atmospheric effect and earth's curvature. This is sometimes referred to as image restoration and rectification. In addition individual subset of images were subjected to image enhancement to improve visual interpretation of the images.

In all, a total of 20 tie points, which included road intersections were used to georeference the 2014 Landsat OLI/TIRS image, in view of the fact that it was the most recent image. The georeferenced image produced a root mean square value of 0.19 which was acceptable because it was within half of a pixel (Jianya *et al.*, 2008). The Nearest Neighbour Resampling (NNR) technique was used for the rectification. This technique has the merit of using the value of the closest input pixel for the output pixel value.

To determine the nearest neighbor the algorithm uses the inverse of the transformation matrix to calculate the image file coordinates of the desired geographic coordinate. The pixel value occupying the closest image file coordinate to the estimated coordinate will be used for the output pixel value in the georeferenced image. The rectified 2014 OLI/TIRS image was used to georeference the 1986 and 2003 TM and ETM images respectively. After rectifying all three bands, they were finally resampled to a 30 m by 30 m pixel resolution to assist in further accurate image analysis of the datasets.

Radiometric corrections were not performed on the images because, the datasets obtained were already corrected by the USGS. Hence there was no need for irregularities between the pixel values recorded by sensors and the spectral reflectance and spectral radiation brightness of the object to be removed or reduced by using radiometric correction techniques.

3.3.4 Image Enhancement

In order to improve visual interpretation, the method of histogram matching was used to normalize images prior to analysis. Histogram Equalized Stretch (HES) was selected among the pool of image enhancing techniques available in Erdas Imagine 9.3. Using this technique, digital values were plotted as a histogram to visualize the frequencies of the occurrence of each digital value. More display values or range was assigned to the frequently occurring portion of the histogram (and stretched within that range), while less range was assigned to the less occurring portion. In doing this, details in frequently occurring values were enhanced relative to those of the original image.

3.3.5 Supervised Classification

After georeferencing and geometric rectification of the images, classification and subsequent extraction of land cover information were executed. Image classification and interpretation were executed using ERDAS Imagine 9.3. In order to extract LULC information, supervised classification was used to categorize the individual features in the images into various land cover classes. Furthermore, execution of ground truthing (i.e 20

GPS points) in the study area enabled an in-depth information to be acquired. This was done by picking 4 GPS ground control points for each land cover class. In view of this information, reliable training samples were selected for all the land cover types. Using the Area of Interest (AOI) tool pallete in ERDAS imagine 9.3, training samples were digitized into polygons for all the land cover types. These training samples were then named appropriately and saved in the signature editor in the classifier tool of ERDAS imagine 9.3. After generation of the signatures, supervised classification tool in ERDAS imagine as well the signatures that were saved and the 1986, 2003 and the 2014 unclassified images were then classified into five land cover types as shown in Table 3.4. The major land cover types or classes used for this study are rock outcrop, bare land, pasture, forest and urban.

Furthermore, Parallelepipeds Maximum Likelihood (Para-ML) classification algorithm was used to produce land cover maps based on the supervised classification methods in Erdas Imagine 9.3. Para-ML method involves the combination of parallelepiped and maximum likelihood classification methods and usage of a decision rule to assess each pixel in an image. In view of this technique, Maximum Likelihood Algorithm (MLA) classified images according to the covariance and variance of the spectral response patterns of a pixel. Also, other land cover classes that could not be identified in any other way were manually digitized over the images and unclassified areas of the images were removed, using the extract by mask spatial analyst tool in ArcGIS 10.2. Unclassified cells of the resultant raster images, were extracted with the aid of the feature mask data defined by digitized boundary of the study area. This enabled area calculations to be done on the final land cover output maps using the zonal geometry tool in ArcGIS 10.2. The results of area calculations, were subsequently exported as Microsoft Excel 2013 compatible file (*.xls).

Table 3.4 Description of the land cover classification system used in the study

Class	Sub Cover Class	Description
Rock Outcrop	Quarry rock	Rock formation that is visible on the earth surface
Bare land	Barren land	Land with less or no vegetation cover and has inadequate resources to support life.
Pasture	Agricultural land	Land used primarily for food and fibre production. This land cover class category includes; cropland and fallow, Ornamental and horticultural areas.
	Grass cover	Areas where vegetation is dominated by grass.
	Water/Wetland	Land areas persistently covered with water, often referred to as water logged areas. This land cover class include lakes, rivers, streams, ponds etc.
Forest	Forest land	Forest lands have a tree-crown areal density (crown closure percentage) of 10% or more, are stocked with trees capable of producing timber or other wood products, and exert an influence on the climate or water regime. Forest lands include deciduous, evergreen and mixed forestlands.
Urban	Urban/Built-up	Land areas made up of infrastructural developments such as roads, buildings, bridges etc.

(Source: Anderson *et al*, 1976)

3.3.6 Accuracy Assessment

After image classification, final output maps that are created for LULCC analysis usually contain some degree of errors. These errors occur as a result of several factors including classification techniques and method for capturing satellite data. In view of these factors, accuracy of the classified maps need to be assessed. Accuracy assessment provide users with more information on where the errors occur. Also, depending on the acceptable level of errors, users are able to determine if the classified images are useable or need reclassification.

In this study, accuracy and Kappa coefficient of the classified images were assessed and determined respectively from the error matrices. Results from these assessments enabled a degree of confidence to be attached to the classified LULCC maps. Calculation of Kappa Coefficient was done using the formula shown below in Equation 1 (Congalton and Green, 1999).

$$K = \frac{n\sum_{i=1}^{r} X_{ii} - \sum_{i=1}^{r}(X_{i+} \times X_{+i})}{n^2 - \sum_{i=1}^{r}(X_{i+} \times X_{+i})} \text{ -- (1)}$$

Where, r = total number of rows in the matrix

n = total number of observations in the matrix

X_{ii} = number in row *i* and column *i*

X_{+i} = total for row *i*

X_{i+} = total for column *i*

Accuracy assessment for the classified LULCC maps was done based on 450 stratified random sampling points, and comparison with a suite of Landsat images (1986, 2003 and 2014), Google Earth images and existing topographical map. The class accuracies were determined by matching ground truth points also known as text pixels with the corresponding ground locations in the classified image. The method of confusion matrix was used to determine the accuracy in ArcGIS 10.2. In all, 30 ground truth reference points were randomly generated for each land cover class making it a total of 150 points for each land cover map under this study (i.e. 1986, 2003 and 2014). These test pixels were evenly disturbed across the reference imagery. The reference points generated, were saved as a new shape file, with unique number codes assigned to each land cover class to match with that of the classified images using the field calculator tool in ArcGIS 10.2.

Furthermore, the new shape file containing the reference points were converted into a raster data using the point to raster spatial analyst tool in ArcGIS 10.2. The raster data obtained for the reference points was then combined with the classified image using the local combine spatial analyst tool. This produced a resultant attribute table indicating the amount of test pixels correctly or incorrectly placed on the land cover classes of the classified images. The attribute table was then exported to a drive location as a database file (*.dbase).

Afterwards, a confusion matrix was created using the pivot table tool under data management in ArcGIS 10.2. Once the pivot table tool was opened, location of the exported attribute table that was earlier saved as a database file was browsed and selected for input table field while the classified image was marked under the input field(s). Also, the reference point raster image and count were selected for the pivot and value fields respectively. The resultant output table was then saved and exported to a drive location as a text file (*.txt). The text file was then opened in Microsoft Excel 2013 and the confusion matrix generated was used for calculating the overall accuracy (Ao) and Kappa coefficient (K) of the classified images chosen years under study.

$$A_O = \sum_{i=1}^{r} \frac{X_{ii}}{n} \quad (2)$$

Where,

r = number of rows in the matrix

X_{ii} = number in row i and column i

n = total number of observations in the matrix

3.3.7 Land Change Modeler for Change Detection

Land Change Modeler (LCM) in Idrisi Selva 17.0 was employed to analyze and model land cover transitions that have taken place between the various land cover classes in the periods under review (i.e. 1986 – 2003, 2003 – 2014 and 1986 – 2014). All three classified images in Erdas Imagine format (.img) were imported into the LCM module in Idrisi Selva software as raster format (.rst). This allowed essential details such as project name and period under review associated with the land cover change analysis to be specified. In order for LCM to effectively evaluate and provide an output map that represents a better understanding of the nature LULCC within a study area, a minimum of two land cover maps are required.

In this study, thematic maps of 1986 – 2003, 2003 – 2014, and 1986 – 2014 were used as inputs in the LCM project parameters. Two thematic maps made up of an earlier land cover image and later land cover image of the same dimensions such as matching backgrounds, legends and spatial characteristics were inserted into the LCM project parameters. The LCM subsequently generated different change output maps and graphs of gains and losses, net change and contributors to the net change by each land cover type. Additionally, LCM performed area calculation in hectare of the various land cover types, to ascertain the amount of LULCC changes that have occurred within the period under review. Results from the LCM analysis were subsequently, presented in Microsoft Excel 2013 software as tables and charts. From these results change in area, extent and annual rate of LULC within the study area were determined using the formulae shown below in Equation 3, 4 and 5.

Change in area (C_a)

$$C_a = T_{a2} - T_{a1} \quad (3)$$

Change in extent (C_e)

$$C_e = \frac{C_a}{T_{a1}} \quad (4)$$

Annual rate of change(C_r)

$$C_r = \frac{C_e}{t_2 - t_1} \quad (5)$$

Where,

T_{a1} = Total area of the beginning year

T_{a2} = Total area of the ending year

t_1 = Beginning year of the LULCC studies

t_2 = Ending year of the LULCC studies

3.3.8 Noise Level Measurement

Field reconnaissance was done to mark out selected areas within the communities using wooden pegs. A total of five locations were marked out based on their proximity to cluster of houses and blasting site. In view of the time frame of this research and the low demand for dimension stones from prospect buyers, a total of five blasts were performed at World Cool Quarry Limited to match each location.

The differences in distance between the selected locations, ranged from 100 m to 200 m. Measurements were taking at distant locations marked out by the wooden pegs within the study area during blasting times at some specific times of the day, to observe the change in sound levels. To quantify the ambient noise levels in the selected locations, continuous ambient noise level measurements and temperature were measured in all five locations. In addition, spatial location of each blast observation point was also measured using a handheld GPS. For each blast measurement, three siren signals were sounded by the blast man in charge before each blast commenced. The time interval between each signal was usually between two or three minutes. This was done to sensitize workers and residents to move to safe places and to indicate the nature of activity about to take place.

The meters of the digital sound level were calibrated before and after use to ensure the accuracy of measurements. Temperature of the environs were also recorded for each observation for all the selected locations using weather app on an HTC android phone. After calibration of the digital sound level meter, it was powered on and readied for subsequent blast noise level measurements. It was held away from the body and at a height of approximately 1.5 m. The "A" frequency weighting was selected by pressing the A/C button on the equipment. This frequency response is similar to the human ear, hence ideal for environmental noise level measurements. Also, "C" frequency weighting is ideal for measuring engine and other mechanical noise levels. Once the third siren was signaled the slow button on the sound level meter was pressed to gradually monitor sound sources that had consistent noise levels.

However, immediately the blast took place, the fast button was quickly pressed, which captured the ensuing noise level. The record (REC) button on the equipment was pressed and noise level for that location duly registered. This method of operation was used for all the other selected distant locations of blast noise observation.

3.3.9 Morbidity and Social Survey

A Semi-structured questionnaires (Appendix B) were self-administered, using a multi-stage (random) sampling technique. The questionnaire contained brief questions designed to obtain reactions from residents and workers of the quarry companies in the study area. The questionnaire was structured into two parts, A and B. Part A, was centered on demographic details of prospective respondents, while B was also made up of the extent of blast noise effect on prospective respondents. This social survey was carried out in the localities of Nkukua Buoho, Ntiri Buoho, Heman Buoho, Afrancho Buoho Sasa, Krobo, and Agyarko Buoho, to obtain subjective assessment of blast noise from residents in the study area. Sample units were selected based on proximity to quarry sites in the study area.

Out of the 75 questionnaires administered, a total of 64 responses were obtained due to lack of collaboration of most prospective respondents and fear of persecution and other personal reasons (Thayer-Hart et al, 2010). Responses for noise related effects were rated according to the level of affirmation of experience from respondents. These ratings were grouped into Strong Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD) (Okoro, 2014). Using statistical analysis, weighted mean ($\bar{X}$) was deduced from the responses as shown below in Equation 6 (Bluman, 2004). The results of blast observations measured in

Aweighted decibels (dBA), were matched against computed weighted mean of each noise related effect from the social survey responses as variable X and Y respectively. These two variables were analyzed statistically with Microsoft Excel 2013 and the results presented in Chapter 4. The results obtained from the social survey and those from the sound level meter were correlated using the Pearson correlation coefficient method. The Pearson correlation coefficient (r) is calculated using the formula shown below in Equation 7.

$$\bar{X} = \frac{w_1 X_1 + w_2 X_2 + \cdots + w_n X_n}{w_1 + w_2 + \cdots w_n} = \frac{\sum wX}{\sum w} \quad (6)$$

Where w_1, w_2, ... , w_n are the weights and X_1, X_2+, ... , X_n are the values.

$$r = \frac{n(\sum XY) - (\sum X)(\sum Y)}{\sqrt{[n\sum X^2 - (\sum X)^2][n\sum Y^2 - (\sum Y)^2]}} \quad (7)$$

Where:

X = Variable of X

Y = Variable of Y

n = Number of data pairs

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Prelude of Results and Discussions

This chapter expounds results and discussions of all classified LULCC maps of the study area during the period under review of this research. Results of accuracy assessment, nature, extent and rate of change of these classified LULCC maps are presented and discussed comprehensively. Additionally, data from exploratory blast noise measurements, noise related health data of the district and interviews of some residents within the study area, are carefully evaluated in this chapter.

4.2 Classification and Accuracy Assessment

The accuracies for 1986, 2003 and 2014 classified maps are shown in Table 4.1, 4.2 and 4.3. Consequently, overall accuracy of 85%, 84% and 94% were obtained for 1986, 2003 and 2014 maps, respectively. As a result, producer's accuracy for the individual maps ranged from 77% to 100% while user's accuracy also ranged from 76% to 100%.

Furthermore, the accuracy assessment process was done using Kappa index calculation. The resultant values of Kappa index were 81%, 80% and 93% for 1986, 2003 and 2014 respectively. These results are significantly better, since higher values tend to produce better and more accurate results (Arsanjani, 2012). Hence, the accuracy of the LULC maps of 1986, 2003 and 2014 were accepted. These maps were then employed in the change detection process.

Table 4.1 Landsat TM classification accuracy for 1986

	Land Cover Types	Bare	Rock Land Outcrop	Pasture	Forest	Urban	Grand Total	User's Acc. %
		Reference Map						
Classified Map	Bare Land	**26**	1	0	0	0	27	96
	Rock Outcrop	2	**27**	0	0	4	33 25	82
	Pasture	0	2 0	**21**	1	1	38	84
	Forest	0	0	9	**29**	0	26	76
	Urban	1	30 90	0	0	**25**	150	96
	Grand Total	30		30 30	30 70	97		
	Producer's Acc. %	87		83				
	Overall map accuracy = 85%							
	Overall Kappa index = 81%							

Table 4.2 Landsat TM classification accuracy for 2003

	Land Cover Types	Bare	Rock Land Outcrop	Pasture	Forest	Urban	Grand Total	User's Acc. %
		Reference Map						
Classified Map	Bare Land	**27**	0	0 2	4 0	0	33 29	82
	Rock Outcrop	0	**29**	0			30 28	100
	Pasture	1	1	**23**	3	2	29	77
	Forest	0	0	5	**23**	0	150	82
	Urban	1	0	2	2	**24**		83
	Grand Total	30	30	30 30	30 77	77		
	Producer's Acc. %	90	97	80				
	Overall map accuracy = 84%							
	Overall Kappa index = 80%							

Table 4.3 Landsat TM classification accuracy for 2014

Land Cover Types	Rock Outcrop	Bare Land	Pasture	Forest	Urban	Grand Total	User's Acc.%
	Reference Map						

Classified Map	Rock Outcrop	**28**	0	1	1 0 0		0	30	93
	Bare Land	0	**29**	0	**29**	0	0	29	100
	Pasture	0	0	**25**	**30**	97	0	25	100
	Forest	0	0	3			0	32	91
	Urban	2	0	1			**30**	33	91
	Grand Total	30	30	30			30	150	
	Producers Acc.%	93	97	83			100		
	Overall Accuracy =94 %								
	Overall Kappa index =93%								

4.3 Land Use Land Cover Change Maps and Statistics

Based on the approaches adopted in the methodology, LULCC output maps were generated for 1986, 2003 and 2014 as shown below in Figures 4.1, 4.2, and 4.3. In addition, area estimates and change statistics were computed. Individual class area and change statistics for all three periods (1986, 2003, and 2014) are summarized in Tables 4.4 and 4.5. The major land cover classes used in this study included bare land, rock outcrop, pasture, forest and urban.

The nature of change analysis of Buoho Township and its surrounding communities revealed change in the sizes of all five LULC classes over the 28 year period of this study. These are captioned under area statistics and percentages of various LULC types and LULC extent and rate of change as indicated in Table 4.5.

Also, for contributions to net change analysis, a positive sign (+) indicates a loss in space of a particular land cover type that has contributed positively to the overall net change in another land cover type. Whereas a negative sign (-) indicates an increase in a land cover type that has contributed negatively to the overall net change in another land cover type under a specific period as shown in Tables 4.7, 4.8 and 4.9.

Table 4.4 Area statistics and Percentage of the land use land cover units in 1986-2014

	1986	**2003**	**2014**

Land Cover Types	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Bare land	35	0.8	378	8.4	820	18.2
Rock Outcrop	325	7.2	214	4.8	538	12.0
Pasture	1368	30.5	2378	52.9	412	9.2
Forest	2572	57.3	923	20.5	190	4.2
Urban	191	4.3	598	13.3	2531	56.4
TOTAL	**4491**	**100**	**4491**	**100**	**4491**	**100**

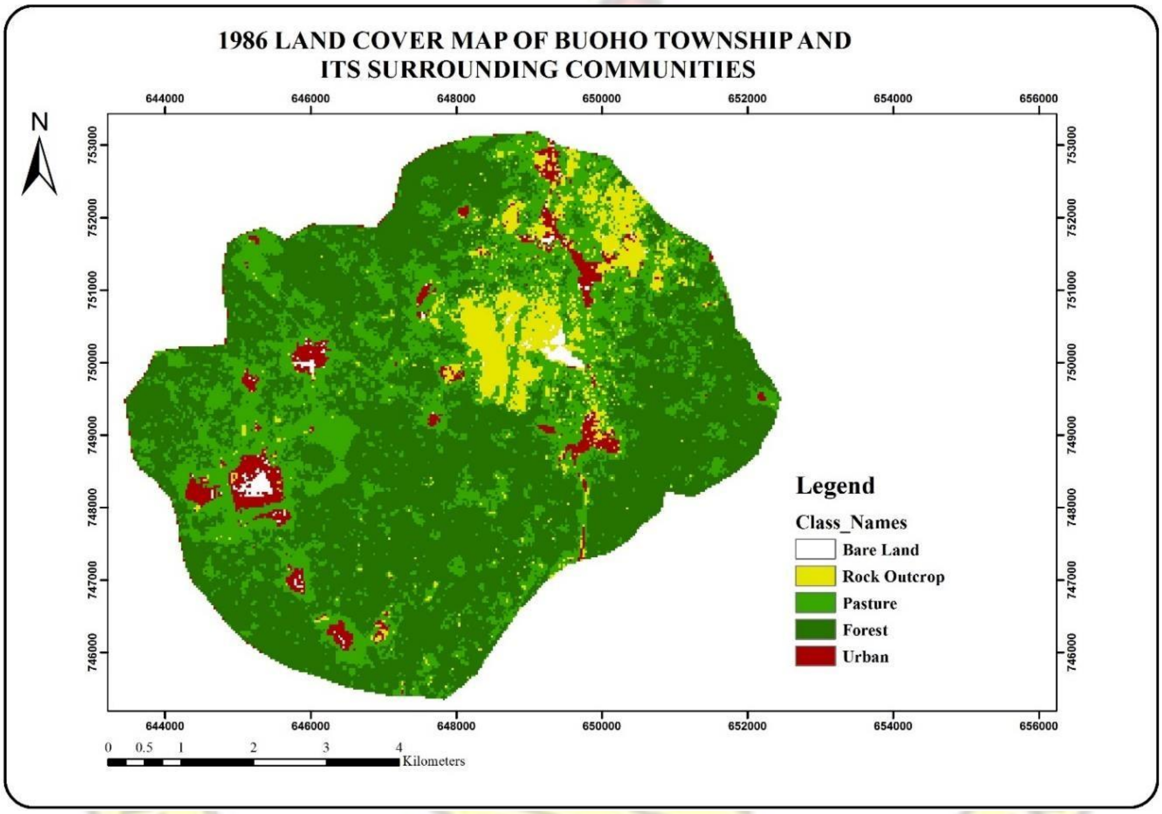

Figure 4.1 Landsat land cover classification of 1986

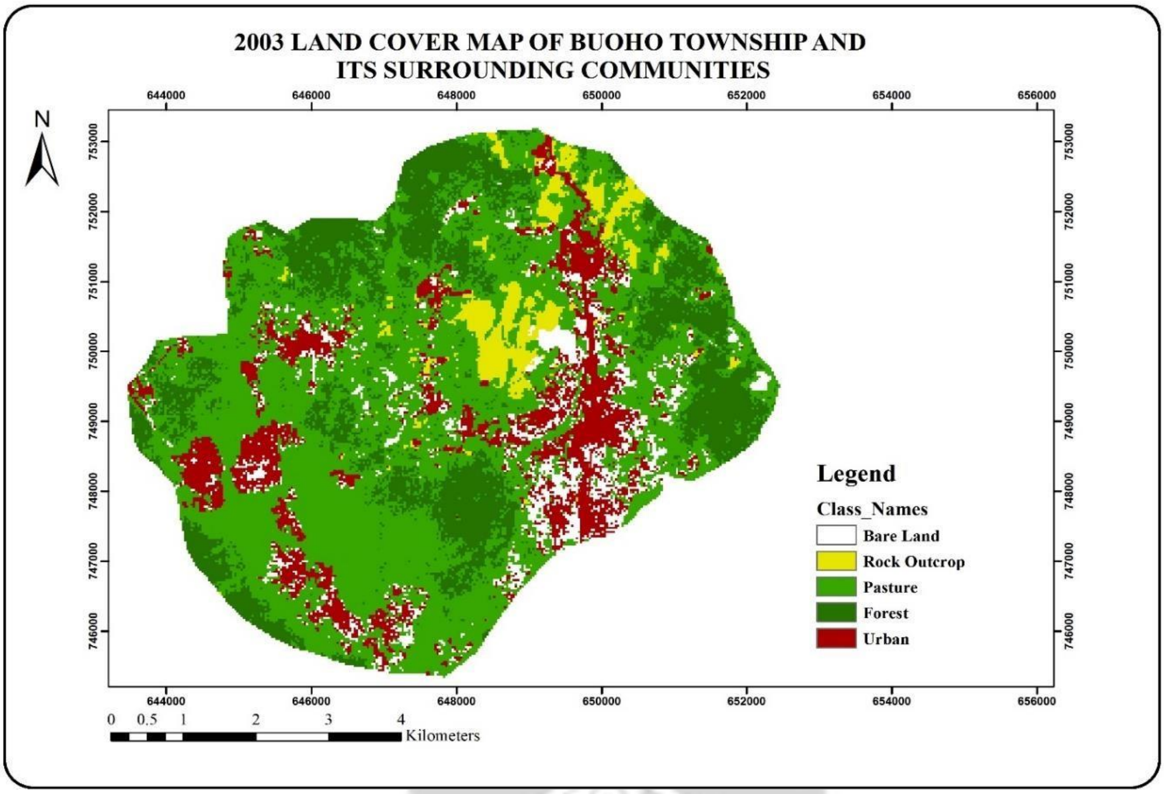

Figure 4.2 Landsat land cover classification of 2003

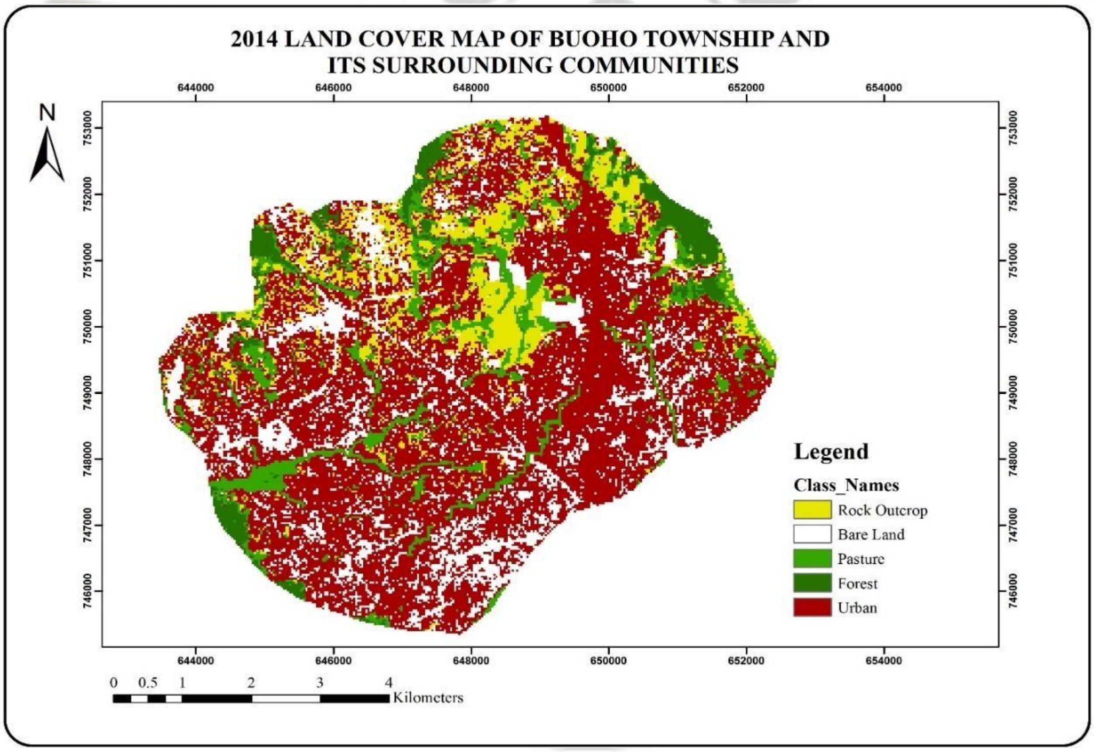

Figure 4.3 Landsat land cover classification of 2014

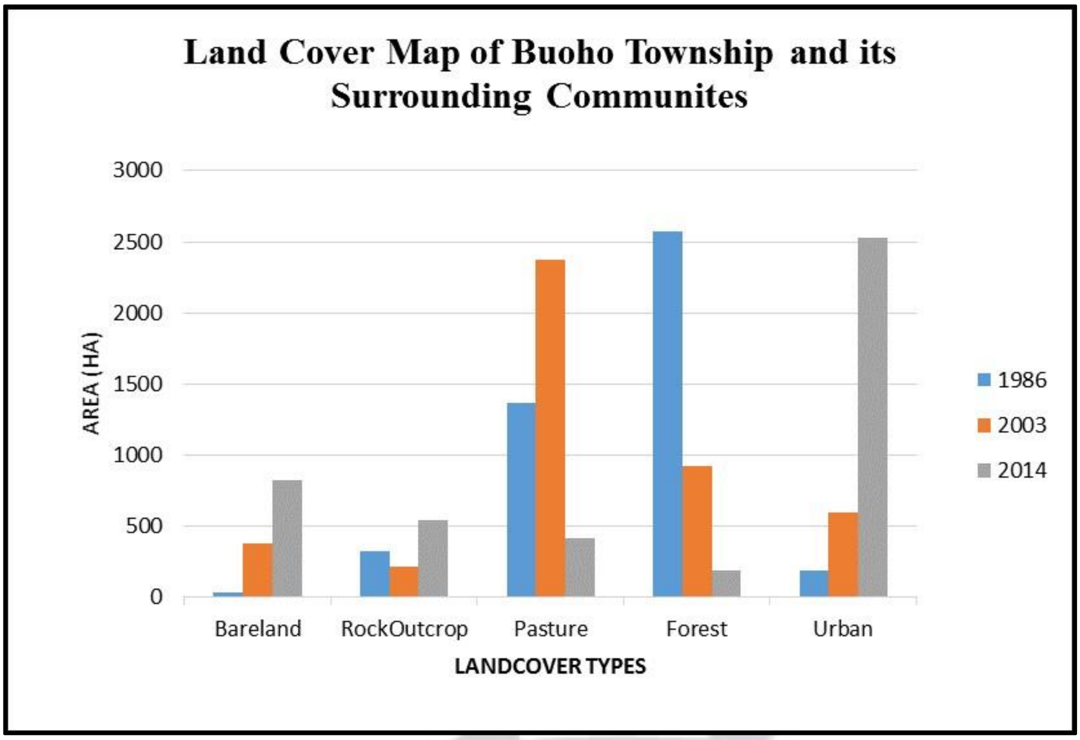

Figure 4.4 Areas statistics of land cover classification of Buoho Township Table 4.5 Overall amount, extent and rate of land cover change (1986-2014)

Land Cover Types	**1986-2003**			**2003-2014**			**1986-2014**		
	Change (Δ/ha)	**Extent (%)**	**Rate of Change (%/yr)**	**Change (Δ/ha)**	**Extent (%)**	**Rate of Change (%/yr)**	**Change (Δ/ha)**	**Extent (%)**	**Rate of Change (%/yr)**
Bare land	343	987	+58	442	117	+11	785	2259	+81
Rock Outcrop	-110	-34	+2	324	151	+14	214	66	+2
Pasture	1010	74	+4	-1966	-83	-8	-956	-70	-3
Forest	-1649	-64	-4	-733	-79	-7	-2382	-93	-3
Urban	407	213	+13	1933	323	+29	2340	1223	+44

The LCM model generated a rapid quantitative assessment of change by graphing gains (+) and losses (-) by land cover category from 1986 to 2003 as shown below in Graph A of Figure 4.5, resulting from the land cover changes. Some form of transition either in gains or losses in all the various land cover types were experienced as shown in Graph A. Also Graph B of Figure 4.5 explained the net change in the period under review. Forest space suffered a huge loss (1858 ha), which enabled pasture space to gain tremendously by 1585 ha as shown in Figure 4.5 and Table 4.6. This transition subsequently caused pasture space to gain the most increment in net change (1010 ha) whiles forest space also experienced the most fall in net change in the year under review as shown in Graph B and Table 4.6.

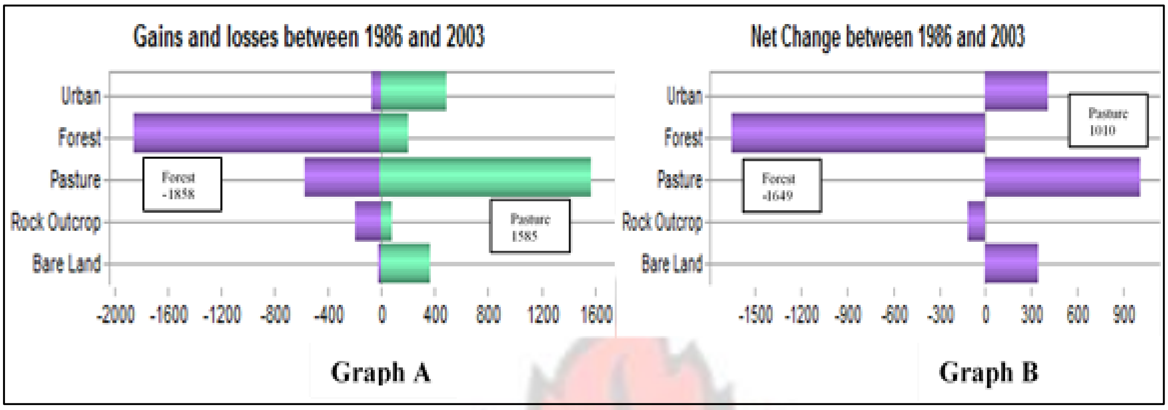

Figure 4.5 LCM of 1986 – 2003 (Area units are in hectares)

Table 4.6 Net change of land cover transitions (1986 – 2003)

Land Cover	1986 - 2003		
	Gain (+)	Loss (-)	Net Change
	Area (ha)	Area (ha)	Area (ha)
Bare Land	363	20	343
Rock Outcrop	83	193	-110
Pasture	1585	576	1010
Forest	209	1858	-1649
Urban	484	77	407

In order to obtain a better comprehension of land cover trends within the period under review, Figure 4.6 and Table 4.7 below, reveal details on contributions to net change in a particular land cover type from 1986 to 2003. This allowed comparisons to be made between various land cover contributors to the net change in a specific land use class or type. In addition, the comparisons enabled identification of land use conversion and suggestion of factors that triggered these transitions.

It is evident from the results obtained in this study that forest and pasture space contributed significantly to changes in the remaining land cover types. In the case of bare land, loss of forest cover contributed positively (+198 ha) to the overall net change (343 ha), while losses in the remaining cover types contributed to its increase as shown above in Figure 4.5 and Table 4.6. Similarly, the immense loss in forest space caused pasture space to experience a significant increase in its overall net change (1010 ha). This positive contribution (+1235 ha) of forest space as a result of it loss, may be attributed to the profligate felling of trees for human and other developmental activities. These activities depletes the forest cover or space and turn the available space into a pasture. Additionally, rock outcrop space contributed positively (+74 ha) to increase in the overall net change in pasture space. The change in weather patterns of the study area especially rainy seasons, cause available unexploited rock outcrop space to be overgrown by weeds, which in turn increase pasture.

Although, the negative contributions of urban rise (-188 ha) and bare land space (-112 ha) could have decreased the overall net change in pasture space, huge loss in forest space (1858 ha) rendered these negative contributions irrelevant, hence maintaining the increment as shown in Table 4.5 and 4.6. Also, the ensuing increase in pasture, bare land, rock outcrop and urban space contributed negatively to the loss in the overall net change in forest space (-1649 ha).

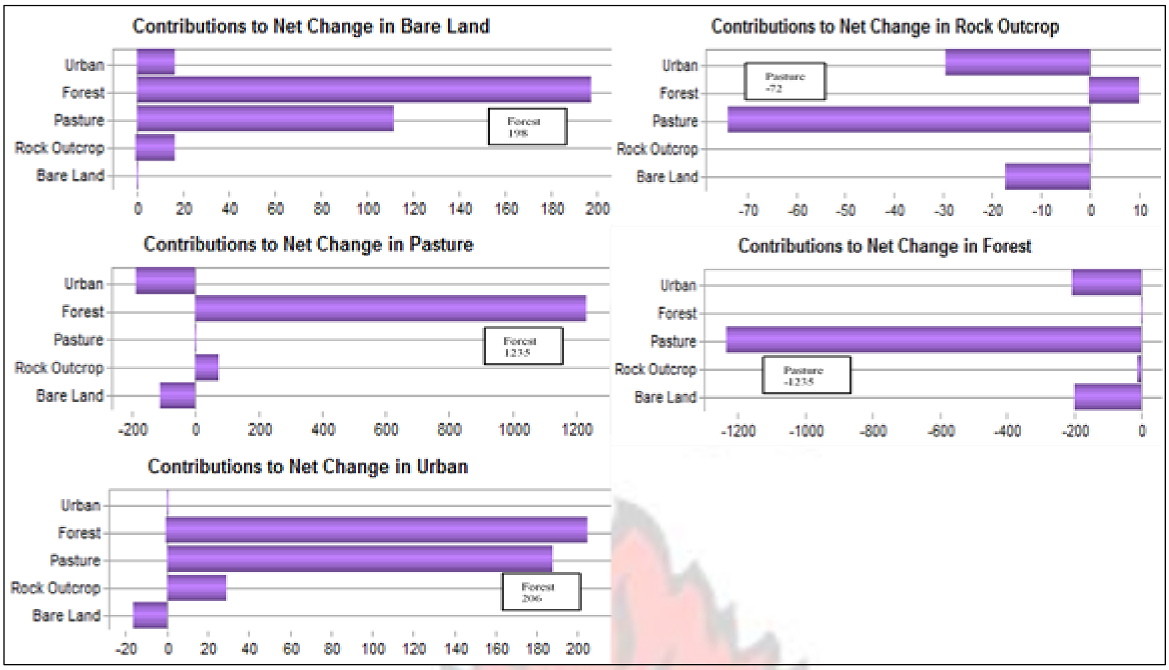

Figure 4.6 Contributions to net change of selected land cover (1986 – 2003)

Table 4.7 Contributions to net change of selected land cover (1986 – 2003)

Land Cover	Bare Land	Rock outcrop	Pasture	Forest	Urban
	Area (ha)	Area (ha)	Area (ha)	Area (ha)	Area (ha)
Bare Land	0	-16	-112	-198	-16
Rock Outcrop	+17	0	+75	-10	+30
Pasture	+112	-74	0	-1235	+187
Forest	+198	+10	+1235	0	+206
Urban	+16	-30	-188	-206	0
Overall Net Change	**343**	**-110**	**1010**	**-1649**	**407**

Furthermore, losses experienced by pasture, forest and rock outcrop space, caused urban space to experience an overall net change of 343 ha. Though, gains in bare land space (16 ha) space meant that it contributed negatively to the overall net change in urban space (407 ha) within the period under review as indicated in Figure 4.6 and Table 4.7. This is because, when some amount rock outcrop, pasture and forest space are lost, an appreciable space is created for developmental projects, which in turn triggers a substantial amount of increase in urban space. Similarly, increase in bare land space may be as a result of activities in the environment such as quarrying which renders the land space fallow and undeveloped, thereby having no positive effect on urban space increment.

In the course of this research several distinct changes occurred on the major LULC types between the periods (i.e. 1986, 2003 and 2014) as shown in Table 4.4 and 4.5. Within the period of 1986 to 2003, bare land increased approximately by 343 ha (987%) while rock outcrop decreased by110 ha (34%). Wetlands, agricultural lands, shrubs and grass cover which make up pasture space also increased appreciably by 1010 ha (74%) as shown in Figure 4.5. Subsequently, forest environment decreased significantly by 1649 ha (64%) while urban space also increased by 402 ha (213%). These land cover dynamics could be attributed to the fact that Buoho Township within that period, relied heavily on the activities of logging and farming as their main source of livelihood. Therefore, as many people acquired lands through clearing of trees, it greatly affected bare land and pasture space. This caused an increase in bare land (987%) and pasture space (74%) while forest environment subsequently decreased by 64%. In addition, the rise of urban space (213%) within that same period could have been the cause of major decline in forest space, exposing footpaths and several open spaces within built up areas of the study area as shown earlier in Table 4.5. These changes served as contributory factors to the decrease in the overall amount of rock space in the year under review.

Rock outcrop space decreased by 110 ha (34%), because within that period there were few quarrying activities taking place in the study area. KAS Quarry Limited was the major quarrying company operating at that time. The company had just began operations and as such, had not really exploited much of its concession. Also, as a result few quarrying activities that was going on, most of the untapped outcrops were gradually overgrown by grasses and weeds hence, covering several rock outcrop space. This trend accounted for the overall decrease in the amount of change in rock outcrop space and the subsequent increase in pasture space (1010 ha) as shown in Table 4.5 and Table 4.6.

In the second period (i.e. 2003 to 2014) of this research, land cover dynamics generated an interesting twist to the earlier changes. The major land cover change within this period was urban space, which increased by1933 ha (323%), whereas bare land increased by 442 ha (117%) as shown earlier in Table 4.5 and Table 4.7 below. This change could be credited to the turn of the twentieth century, which brought a lot of growth across the country in terms of industrialization and population growth. Losses and gains in net change for each land cover class within the period under study are indicated below in Figure 4.7 and Table 4.8.

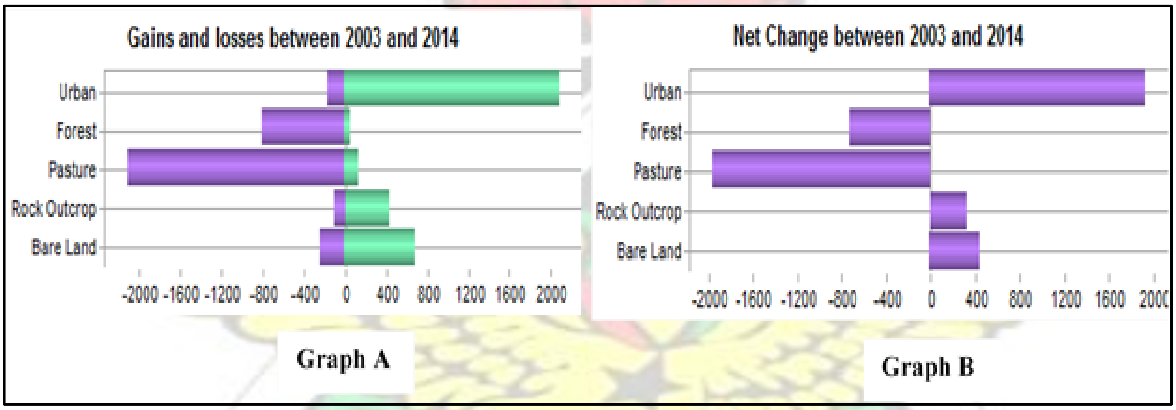

Figure 4.7 LCM of 2003 – 2004

Table 4.8 Net change of land cover transitions (2003 – 2004)

Land Cover	2003-2014		
	Gain (+)	Loss (-)	Net Change
	Area (ha)	Area (ha)	Area (ha)
Bare Land	689	247	442
Rock Outcrop	427	103	324
Pasture	146	2111	-1966
Forest	71	804	-733
Urban	2097	164	1933

It can be seen in Graph A of Figure 4.7 above that various form of transitions either in gains or losses, were experienced in all the land cover types. Analysis of net change, depicting all land cover changes that have occurred during the period under review is also, shown in

Graph B. Pasture space suffered huge losses (2111 ha) while urban space gained tremendously by 2097 ha as shown in Figure 4.7 and Table 4.8.

Furthermore, contributions to net change of land cover types in the period under review are shown below in Figure 4.8 and Table 4.9 respectively. Contributions to net change in bare land space, revealed that losses in pasture, forest and rock outcrop space, contributed positively (+392 ha), (+130 ha) and (+6 ha) respectively to the increase in the overall net change in pasture space even though, gains in urban space contributed negatively (-86 ha). Similarly, contributions to net change in rock outcrop space showed pasture and forest as the major contributing factors to its increase in the overall net change (324 ha) as indicated below in Table 4.9.

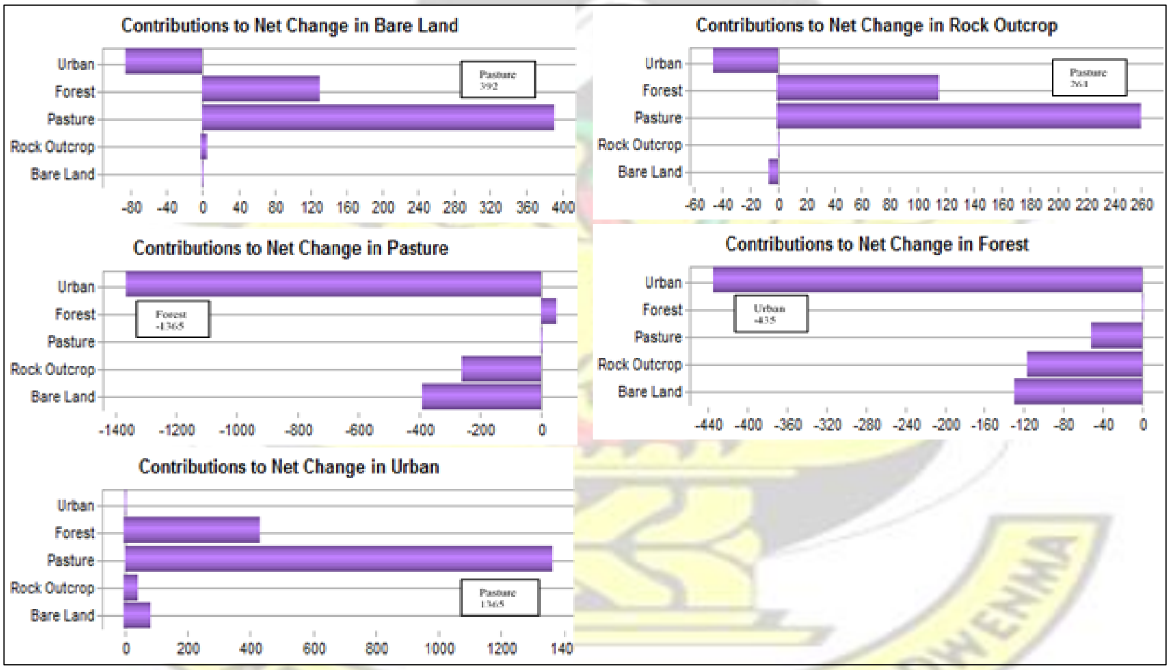

Figure 4.8 Contributions to net change of selected land cover (2003 – 2014)

Table 4.9 Contributions to net change of selected land cover (2003 – 2014)

Land Cover	Bare Land	Rock outcrop	Pasture	Forest	Urban
	Area (ha)	Area (ha)	Area (ha)	Area (ha)	Area (ha)
Bare Land	0	-6	-392	-130	+86
Rock Outcrop	+6	0	-261	-116	+47

Pasture	+392	+261	0	-52	+1365
Forest	+130	+116	+52	0	+435
Urban	-86	-47	-1365	-435	0
Overall Net Change	**442**	**324**	**-1966**	**-733**	**1933**

Under this period, urban space was the major land cover type, which contributed immensely (-1365 ha) to the overall net change in pasture space. Gains in urban, rock outcrop and bare land space meant that they contributed negatively to the overall net change in pasture (-1966 ha) with the exception of forest space, which contributed positively (+435 ha) due to its loss as shown above in Figure 4.8 and Table 4.9. Additionally, contributions to net change in forest space showed that huge increase in urban space under this period, contributed negatively (-1365 ha) to the overall net change in forest space (-733 ha). Contributions to net change in urban space within the period under review revealed pasture and forest space as the major contributing factors. Consequently, losses in forest (+1365 ha) and pasture space (+435 ha) contributed positively to the increase in the overall net change in urban space (1933 ha) with their losses as shown in Table 4.9.

Furthermore, happenings of these contributory factors, could be attributed to the upsurge of urbanization and quest for businesses to expand during the period under review. This put a lot of pressure on the central business district of the regional capital (Kumasi) and its surroundings. In view of this, Buoho Township experienced an astronomical increase in urban (1933 ha) and bare land space (442 ha) as revealed in Figure 4.7, Table 4.8 and Table 4.9. This astronomical increase, could be as result of numerous acquisition of lands and expansion in built up areas within the township and surrounding communities by prospective residents. These changes in urban and bare land space put a lot of pressure on the rock outcrop, forest and pasture cover within the period. However, forest cover was heavily affected as it decreased by 733 ha (79%).

Also, most residents abandoned farming activities for other viable source of livelihood as some quarry activities started increasing. Most lands belonging to the inhabitants were subsequently, sold to prospective settlers. Pasture was the worst affected as it decreased 1966 ha (83%) as shown in Table 4.5 and 4.9 as result of pressures from urban space, quarry sites and acquisition of bare lands for building and other developmental purposes. Additionally, as several residents moved into the study area, built up (urban) and bare land areas increased considerably. These changes, subsequently caused a significant amount of rock outcrops to be exposed from the clearing of weeds and pasture space for construction activities such as roads and buildings, resulting in the increase of rock outcrop space.

Rock outcrop space, increased by 324 ha (151%) remarkably as shown in Table 4.5 and 4.9. This remarkable increase presented viable rock outcrops for prospective quarrying companies in the study area. Also, the availability of improved road networks within the study area meant that haulage of dimension stones to prospective customers would be easily executed. In view of these indicators several quarrying companies started operations in the year under review. The upsurge in quarrying activities caused exploitation of an appreciable amount of rock outcrop space on the operational concessions, thus turning the exploited areas into bare surfaces. Therefore, a sharp decline in pasture space by 1966 ha was experienced during the year under review.

In the course of the 28 year period of this study, urban and bare land space experienced most amount of gain, while forest and pasture space experienced most amount of loss and as shown below shown below in Graph A and B of Figure 4.9 and Table 4.10.

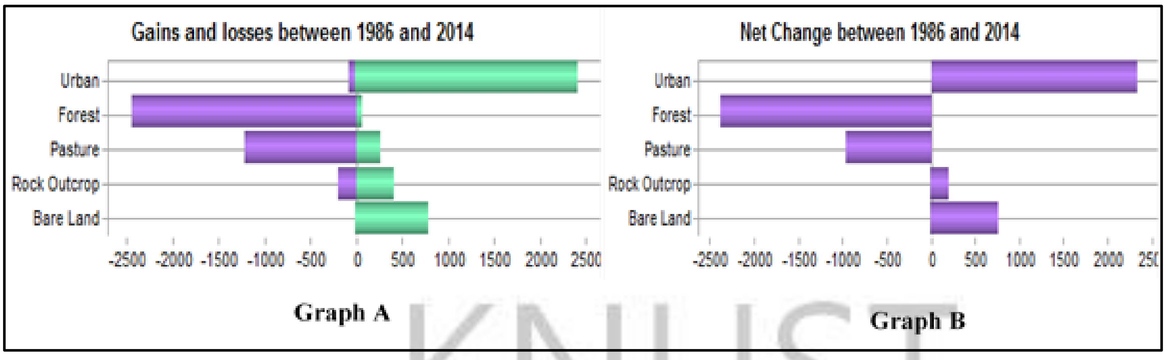

Figure 4.9 LCM of 1986 – 2014

Table 4.10 Net change of land cover transitions (1986 – 2014)

Land Cover	1986-2014		
	Gain (+)	Loss (-)	Net Change
	Area (ha)	Area (ha)	Area (ha)
Bare Land	798	14	785
Rock Outcrop	410	196	214
Pasture	261	1218	-956
Forest	64	2445	-2382
Urban	2427	87	2340

Contributions to net change in bare land, revealed huge losses in forest and pasture space as the major contributing factors in the total increase in net change for bare land space (785 ha) as shown in Figure 4.10 and Table 4.11. The losses in pasture and forest space contributed positively by +762 ha and +1523 ha respectively to the increase in urban space. Similarly, pasture and forest space contributed positively to the increase in the overall net change in rock outcrop space (214 ha) as shown above in Graph B of Figure 4.9. Moreover, losses in pasture and forest space gave rise to subsequent increase in rock outcrop space even though there were increase in urban and bare land space which impacted negatively by -110 ha and -31 ha respectively. However, positive contributions of pasture (+134 ha) and forest (+220 ha) far outweighed that of urban and bare land space.

Also, contributions to net change in pasture revealed urban space as the main contributing factor to the loss in the overall net change experienced during the period under review.

Increase in urban space contributed negatively (-762 ha) to loss of pasture space even though there was some amount of loss in forest space which could have contributed positively (+177 ha) as shown below in Table 4.11.

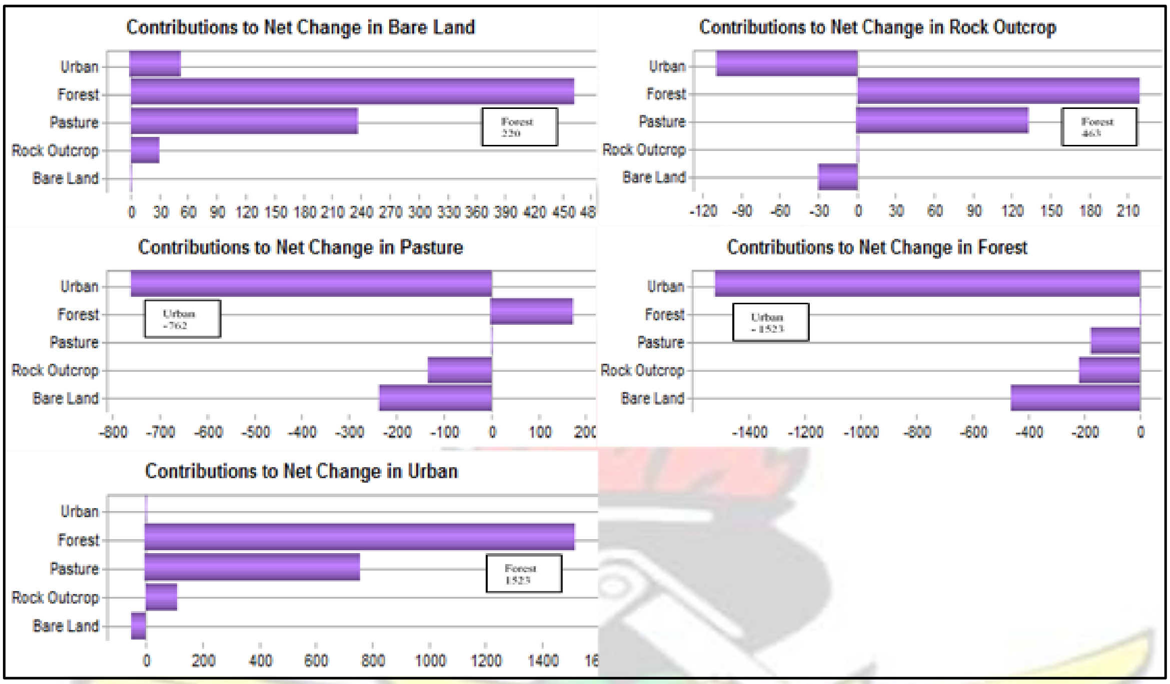

Figure 4.10 Contributions to net change of selected land cover (1986 – 2014)

Table 4.11 Contributions to net change of selected land cover (1986 – 2014)

Land Cover	Bare Land	Rock outcrop	Pasture	Forest	Urban
	Area (ha)	Area (ha)	Area (ha)	Area (ha)	Area (ha)
Bare Land	0	-31	-237	-130	-54
Rock Outcrop	+31	0	-134	-116	+110
Pasture	+237	+134	0	-52	+762
Forest	+463	+220	+177	0	+1523
Urban	+54	-110	-762	-435	0
Overall Net Change	**785**	**214**	**-956**	**-2382**	**2340**

Contributions to net change in forest showed gain in the remaining land cover types (i.e. urban, rock outcrop and bare land) as the catalyst in the ensuing huge loss experienced by forest space during the period under review (i.e. 1986 – 2014). In addition, contributions to net change in urban space showed pasture and forest space as the main contributing factors.

Losses in pasture and forest space contributed positively by +762 ha and +1523 ha respectively to the increase in urban space as shown in Table 4.11.

It can be inferred, as shown earlier in Table 4.5 and Table 4.11 above that between the 28 year period (i.e. 1986 to 2014), the major land cover types that were greatly depleted were pasture and forest space i.e. 956 ha (70%) and 2382 ha (93%) respectively. This trend could be as a result of the huge demand for land acquisition and subsequent migration from city centres to the study area for accommodation and developmental purposes, which clearly caused the upsurge in urban space by 2340 ha (1223%) and bare land 785 ha (2259%). Rock outcrop space also showed a steady increase of up to 214 ha (66%).

Therefore, in an ideal situation rock outcrop space would have been expected to drop but that was not the case within the 28 year period. This is because the study area is endowed with vast rock formations hence, the steady increase in rock outcrop space is a result of depletion in pasture and forest space and increase in urban areas therefore, exposing new viable rock outcrops. As a result of this trend, the study area will continue to serve as an ideal hub for quarrying activities for many prospective and existing quarrying companies. This in turn will lead to rapid expansion of quarrying activities coupled with continuous increase in built up areas, thereby exposing residents living in the study area to a lot of environmental issues from the quarrying companies. These indicators raise a lot of environmental concerns, which need to be addressed.

4.4 Observation of Blast Noise Levels

Details of distances from blast site, ambience noise levels, recording times and some meteorological conditions such as temperature prevailing during observations were recorded for this research as shown below in Table 4.12. The table contains results of ambient noise levels and average blast noise values. As sound travels through the atmosphere from the source to the receiver, noise levels attenuate (i.e. decrease) depending on ground absorption characteristics, atmospheric conditions, and presence of physical barriers such as the nature of the terrain.

In this study, noise levels obtained (70.4 dBA, 58.1 dBA and 50.5 dBA) during the ambient noise measurements for observation sites 2, 4 and 5 respectively were fairly low. However, there were increases in ambient noise levels at observation site (OS) 1 and 3 as shown below in Table 4.12.

Table 4.12 Ambient and blast noise levels at World Cool Quarry Limited

Observation Site (OS)	Distance from Blast Point (m)	Ambient Noise Level (dBA)	Blast Noise Level (dBA)	Time (GMT)	Temperature (ºC)
1	203	83.7	121.2	3:51 PM	30
2	401	70.4	115.7	16:20pm	28
3	747	74.8	109.5	11:35am	27
4	936	58.1	100.6	14.00 pm	28
5	1340	50.5	92.4	15:20 pm	28

(Source: Field observation, 2015)

At a distance of 203 m from the blast point, the elevated ambient noise reading was 83.7 dBA at OS 1. This was caused by operational activities at the quarry premises such as milling of boulders into dimension stones and haulage by heavy duty trucks, culminating in the sharp rise of the ambient noise level. At OS 2 (401 m), the ambient noise level recorded was 70.4 dBA, which was a sharp decline from what was recorded at OS 1. This could be attributed to the huge number of new houses that have been constructed within the vicinity. Most of the residents were indoors hence, there were little activities taking place outdoors during the period of observation. There were also occasional passage of haulage trucks along the main road leading to the quarry site.

Ambient noise levels at OS 3 (72.4 dBA) was observed within the village centre of NtiriBuoho at a distance of approximately 747 m away from the blast point. The rise in ambient noise level recorded at this point could be attributed to the various noise sources that emanated from little children that were playing around, blaring of music from speakers in and outside the rooms of residents and moving vehicles along the main road. OS 4 and 5 as shown in Table 4.7 recorded lower ambient noise levels of 58.1 dBA and 50.5 dBA respectively. These observation sites were a bit farther away from the village centre and blast point at distances of 936 m and 1340 m respectively with fewer houses scattered around the vicinity. In view of this, not much activity was going on at these sites but rather occasional passage of vehicles and intermittent blaring of music from nearby houses.
Ghana's permissible ambient noise level for residential zone, is 55 dBA for day and 48 dBA for night as shown Appendix A of this study; ambient noise levels recorded, indicated high noise levels above the permissible limits except for OS 5.

Furthermore, blast noise measurements recorded at OS 1 (121.2 dBA) and OS 2 (115.7 dBA) were very high and as a result posed a lot of risk to residents around the quarry site. These risks were heightened due to the close proximity of residents to the blast point at distances of approximately 200 m and 400 m respectively. Aside from the health risks that residents were exposed to, buildings and the environment in general, were also heavily affected by dust and chemical emissions from the aftermath of each blast as shown in Appendix C1.The high blast noise levels at OS 1 and 2 resulted in huge ground vibrations across the study area that caused buildings to shake and fly rocks to fall into homes of residents. Subsequently, aftershock from the blast generated high levels of annoyance, fear and panic within the neighbourhoods.

Moreover, the drop in blast noise levels at distances of 747 m, 936 m and 1340 m away from blast point at OS 3, 4 and 5, as recorded were 109.5 dBA, 100.6 dBA and 92.4 dBA respectively. The results obtained, were clearly are above the EPA of Ghana's standards for predominantly heavy duty areas as shown in Appendix A of this research. However, Benin (2007) recommended that induced blast noise levels should range from 115 dBA to 120 dBA or less for annual periods. Hence, the induced blast levels recorded at OS 1 exceeded this permissible limit, which could have adverse impact on the health of residents. In view of these noise level dynamics obtained for this study, it can be deduced that as observation sites move farther away from the blast point into the communities towards the outskirts, blast noise levels also decreases steadily. This goes to confirm the general notion that noise diminishes as distance increases from the point source (Nunez, 1998).

Furthermore, the health impacts of environmental noise i.e. blasting noise are a growing concern among both the general public and policy makers in Ghana. Prolonged exposures usually leads to ear infection and other dust related ailments such as asthma, pneumonia, upper respiratory infection (URT) from the smoke and dust resulting from blasting and other quarry activities as discussed in Chapter 4.1.

4.5 Health Data

There is an enormous environmental risk experienced by communities where quarrying activities take place through exposure of noise and other environmental related pollution as indicated below in Figure 4.11. These risks arise directly through quarry activities that introduce noise, dust and other environmental hazards, and indirectly through the migration of social structures. The effects of noise on health, operate through a number of pathways including direct effects, interference with cognitive processes and general wellbeing through reaction to interference in daily activities and communications. Summary of Outpatient morbidity data as shown below in Figure 4.11, indicate various health cases experienced in the study area and its surrounding communities.

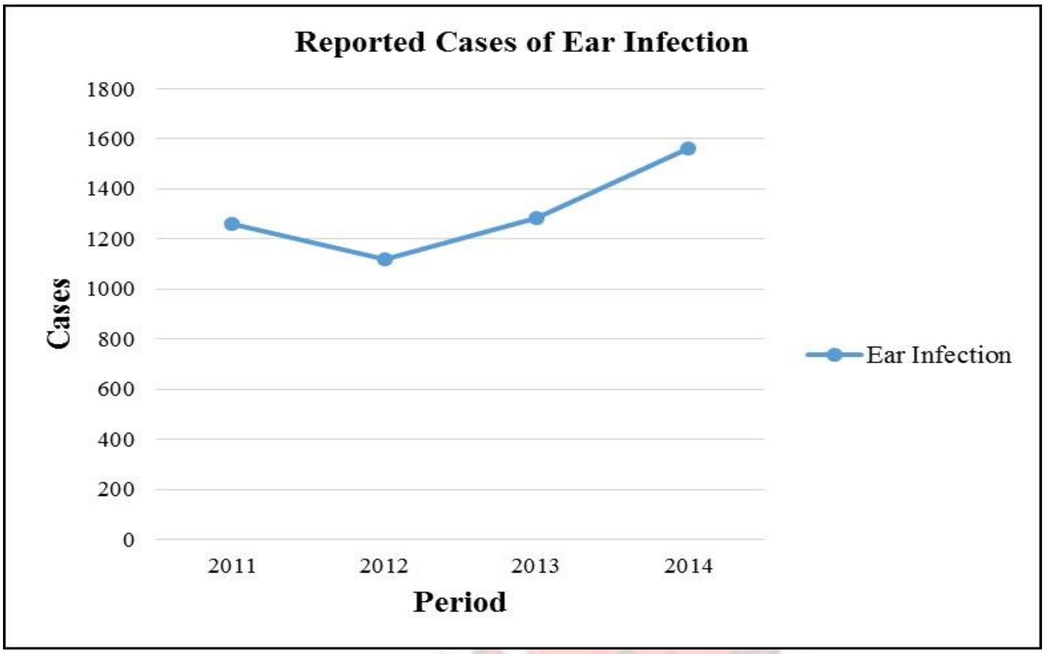

Figure 4.11 Outpatient morbidity returns for Afigya Kwabre district

Reported cases of noise related diseases such as ear infection, indicated a sharp rise in the year 2014 (1,560) compared to the previous years of 2011 (1,260), 2012 (1,121) and 2013 (1,283) respectively. Although, year 2012 (1,121) showed a drop in reported cases, a sustained rise in the number of cases was observed for 2013 (1,283) through to 2014 (1,560). Although there were emergence of quarrying companies within these periods under review, a drop in number of cases for 2012, could be attributed to low demand for quarry products from customers, which in turn would mean low blasting activities and subsequently less effect on surrounding communities.

Additionally, continuous increase in noise activities generated by the various quarrying companies and load and haul operations by heavy duty trucks seem to suggest the reason for the increase in complains of ear-related diseases during these periods. Beside the noise and vibration generated after blasting, dust exposed into the atmosphere might have also caused a lot of ailments such as, asthma, pneumonia, tuberculosis and Upper Respiratory Tract (URT) infections as shown in Table 4.13. URT cases showed a sharp rise in cases from the year 2011 (15,411) to 2014 (18,680) as shown in Table 4.13. Even, though asthma recorded lower number of cases throughout the years as compared to URT infections, it revealed a rise in cases from 508 (2011) to 625 (2013), which could be attributed to the emergence of new quarry companies.

Table 4.13 Outpatient morbidity returns for Afigya Kwabre district

Case	2011	2012	2013	2014
Ear Infection	1260	1121	1283	1560
Asthma	508	407	625	555
Tuberculosis	25	14	2	
Pneumonia	540	303	539	579
Upper Respiratory Tract Infections	15411	15534	16888	18680

(Source: AKDHD, 2014)

However, there was a drop in reported cases of asthma in the year 2012 (407). Similarly, this brief drop could have resulted from the low demand for quarry products from customers, thus affecting the amount of blasting activities that might have taken place during this period. The upsurge in dust related diseases as shown in Table 4.13, could be attributed to the lack of proper watering of various quarry sites and haulage roads in the communities. Most of these dust filled quarry premises and haulage roads are hardly watered to the detriment of residents.

4.6 Social Survey Results

Results from the social survey conducted, was obtained by the use of a self-administered multi-stage questionnaire to quantify views of residents on the blast noise effect on them. The questionnaire was made up of four (4) degrees of response namely SA (4), A (3), D (2) and SD (1) showing strongly agree, agree, disagree and strongly disagree respectively. Also, how often respondents experienced noise related ailments were accessed. A summary of blast noise effect and percentages of respondents who have been sick due to these exposures are shown in Table 4.14 and 4.15 and Figure 4.12 below.

Table 4.14 Responses and response percentages of noise effect

Option	Response	Percentage (%)
Always	11	17
Occasionally	21	33
Rarely	32	50
Total	**64**	**100**

Responses from residents indicated that 17% experienced one or more noise related effects such as annoyance, tinnitus, headache, sleeplessness and cardiovascular effects as shown in Table 4.9. 33% experienced these effects in the study area whiles 50% respondents rarely or scarcely experienced these noise related effects.

Noise effect from blasting activities within the study area as shown below in Table 4.15 indicate that 26 and 18 respondents strongly agreed and agreed respectively to the annoyance these blasting activities had brought to them. They expressed their disgust for the sheer neglect of basic safe environmental practices associated with the blasting activities by these companies such as regulated blast time for the various communities. In contrast, 12 respondents disagreed while 8 respondents strongly disagreed to the annoyance generated by these blasting activities. They expressed less concern about the blasting activities and that could be attributed to their remoteness from the blast source.

Table 4.15 Summary of response of blast noise effects

Blast Noise Effects	**Responses**			
	SA	A	D	SD
Annoyance	26	18	12	8
Tinnitus	2	21	29	12
Headache	6	33	14	11
Sleeplessness	3	19	31	11
Cardiovascular effect	2	3	44	15

Furthermore, with regards to symptoms of tinnitus from the continuous noise exposure of blast noise, plant operations and heavy duty haulage trucks showed that 2 of the respondents strongly agreed whiles 21 agreed. Respondents attributed their affirmation of tinnitus to the high levels of blast noise and ground vibration; producing continuous ringing sound in the ears. Most of these respondents lived in close proximity to the blast source hence their affirmation to tinnitus. However, respondents who disagreed (29) and strongly disagreed (12) attributed their assertion to their remoteness from blast noise, hence their freedom from these symptoms.

Headaches and minor migraine, as a major health problem experienced by respondents showed that 6 and 33 strongly agreed and agreed respectively whiles the rest disagreed (14) and strongly disagreed (11). These respondents attributed the onset of headaches and minor migraines to the continuous blasting activities. They asserted that blasting usually produced high noise levels triggering these headaches and migraines. Those in disagreement, indicated their non-availability in the study area due to work related and personal activities during blasting times. In addition, the effect of sleep disturbance experienced by respondents as a result of the continuous blasting were quantified as strongly agreed (3) and agreed (19). Nursing mothers have had a hard time putting their babies to sleep as result of the noise levels. Those in disagreement attributed their response to the fact that they were mostly unavailable during blast times and also due to the remote location of their houses from the blast source. About 31 disagreed whiles 11 strongly disagreed with experiences of sleep disturbance. Most of these respondents lived very far away from the blast source and therefore had less impact from the blasting activities.

Few respondents strongly agreed (2) and agreed (3) to having experienced cardiovascular effect as a result of blast noise levels. These could be as result of fear and panic they experienced anytime the blast went off, subsequently causing their blood pressure, heartbeat and stress levels to rise. However, majority of respondents disagreed (44) and strongly disagreed (15) to experiencing these cardiovascular effects.

Furthermore, duration of occupancy of respondents are shown below in Figure 4.12. In all, 59% of respondents have lived in the study area for less than 5 years, 22% (5 - 10 years), 13% (11 - 20 years) and 6% less, for more than 20 years.

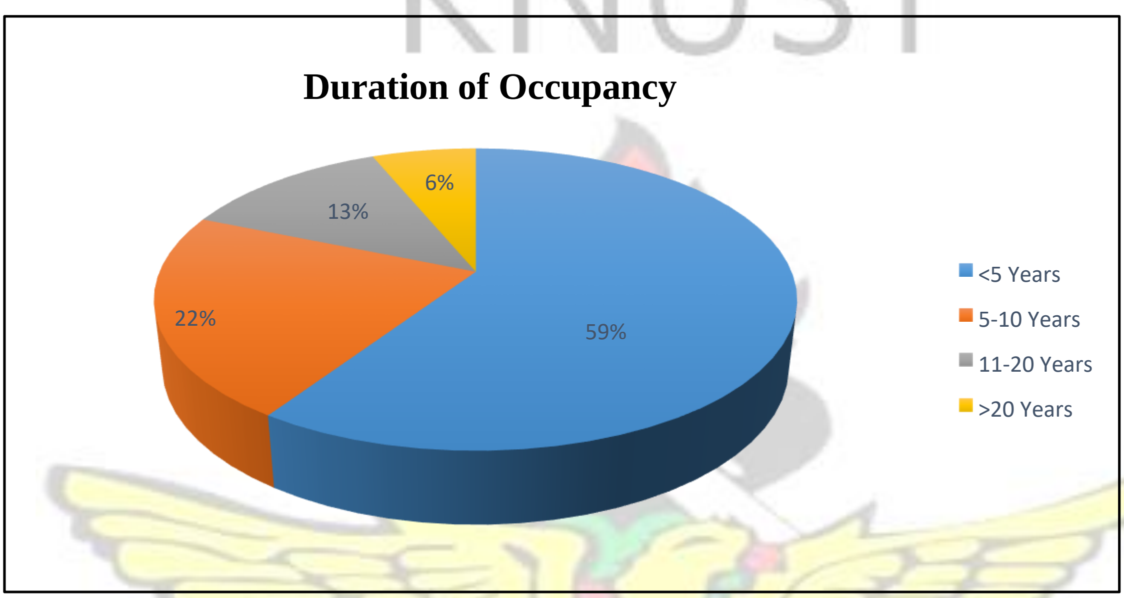

Figure 4.12 Duration of occupancy of respondents within the study area

The high percentage of residents (59%), who have lived for less than 5 years in the study area could be attributed to the increase rate of migration of residents into the study area. These residents are scattered around vicinities in close proximity to quarry centres or companies. Also, the fewer percentages recorded for the other duration of occupancies of respondents could be explained as residents who live farther away from the study area and quarry companies as shown above in Figure 4.12.

4.7 Statistical Correlation between Blast Noise Observation and Social Survey

Results of the computed weighted mean for each noise related effect, is shown below in Table 4.16 (Bluman, 2004; Okoro, 2014). In addition, field exploratory blast noise observations and weighted mean for each noise related effect enabled correlation coefficient to be calculated as shown below in Table 4.17 and Table 4.18. Mean weight ratings for the various noise related effects showed relatively high values for annoyance (19.00), tinnitus (14.10), headache (16.20), sleeplessness (14.20) and cardiovascular effects (12.00). These values show the extent to which blasting activities impact on the residents living in the study area.

Table 4.16 Statistics of blast noise effect rating on noise related effects

Annoyance						
Noise effect Ratings (w)				Weight ($\sum wX$)	Total Ratings ($\sum w$)	Weighted Mean ($\sum wX/\sum w$)
SA(4)	A(3)	D(2)	SD(1)			
No. of Respondents (X)				190	10	19.0
26	18	12	8			
Tinnitus						
Noise effect Ratings (w)				Weighted Rating ($\sum wX$)	Total Ratings ($\sum w$)	Weighted Mean ($\sum wX/\sum w$)
SA(4)	A(3)	D(2)	SD(1)			
No of Respondents (X)				141	10	14.1
2	21	29	12			
Headache						
Noise effect Ratings (w)				Weighted Ratings ($\sum wX$)	Total Ratings ($\sum w$)	Mean ($\sum wX/\sum w$)
SA(4)	A(3)	D(2)	SD(1)			
No of Respondents (X)				162	10	16.2
6	33	14	11			
Sleeplessness						
Noise effect Ratings (w)				Weight ($\sum wX$)	Total Ratings ($\sum w$)	Weighted Mean ($\sum wX/\sum w$)
SA(4)	A(3)	D(2)	SD(1)			
No of Respondents (X)				142	10	14.2
3	19	31	11			
Cardiovascular effect						
Noise effect Ratings (w)				Weight ($\sum wX$)	Total Ratings ($\sum w$)	Weighted Mean ($\sum wX/\sum w$)
SA(4)	A(3)	D(2)	SD(1)			
No of Respondents (X)				120	10	12.0
2	3	44	15			

Table 4.17 Data set for correlation of blast noise and social survey

Blast Noise Observation (OS) (dBA) (X)	**Weighted Mean for Noise Related Effects (Y)**
121.2	19.0
115.7	14.1
109.5	16.2
100.6	14.2
92.4	12.0

Based on the variables X and Y shown in Table 4.17, correlation coefficient (*r*) was computed using the procedure table in Microsoft Excel 2013 as shown below in Table 4.18.

Table 4.18 Procedure table for finding correlation coefficient (*r*)

Data	**(X)**	**(Y)**	**XY**	**X^2**	**Y^2**
1	121.20	190.00	2302.80	14689.44	361.00
2	115.70	14.10	1631.37	13386.49	198.81
3	109.50	16.20	1773.90	11990.25	262.44
4	100.60	14.20	1428.52	10120.36	201.64
5	92.40	12.00	1108.80	8537.76	144.00
n = 5	$\sum X$ = **539.40**	$\sum Y$ = **75.50**	$\sum XY$ = **8245.39**	$\sum X^2$= **58724.30**	$\sum Y^2$ = **1167.89**

$$r = \frac{n(\sum XY)-(\sum X)(\sum Y)}{\sqrt{[n\sum X^2-(\sum X)^2][n\sum Y^2-(\sum Y)^2]}}$$

$$r = \frac{5(8245.39)-(539.4)(75.50)}{\sqrt{[5(58724.30)-(539.40)^2]-[5(1167.89)-(75.50)^2]}} = 0.82$$

The correlation coefficient (*r*) of 0.82 was obtained from the analysis. A positive correlation coefficient of 0.82, indicates a strong correlation between blast noise observations and social survey results.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study enabled LULCC maps of Buoho Township and its surrounding communities to be created for the years: 1986, 2003 and 2014, demonstrating the application of remote sensing technique as essential tool for evaluating, monitoring and understanding the nature and extent of change over a twenty eight year period. In addition, noise exposure from blast noise generated by quarrying activities and other environmental concerns may be related to the health status of residents in the study area.

1. **What is the nature of LULCC that has taken place from 1986, 2003 and 2014 in the study area?**

The quantitative testaments of land use pattern obtained in this study, revealed a steady increase in rock outcrop and an exponential growth in bare land and urban space. However, pasture and forest space suffered an exponential decline during the study period of 1986, 2003 and 2014.

2. **What is the extent and rate of LULCC that has taken place within the 28 year period of this study?**

Conversions of forest, pasture and agriculture lands to bare land and urban space represent the most prominent land cover change due to quarry activities and urbanization. The rate of change was as high as 81% for bare land space and 44% for urban space per year. There was also a steady increase in rock outcrop at 2% per year, which could be attributed to the subsequent rise in urban and bare land space exposing some amount viable rock outcrops. Therefore, this trend places the study area as an ideal hub for more expansion in quarrying activities by prospective and existing companies.

However, forest space decreased at a yearly rate of 3% as against 2% of pasture over the period under study. The growth of urban area has taken over close vegetated lands including forest, pasture and agricultural lands leaving the study area derelict of vegetation causing general degradation of the environment.

The trend and extent of urban and bare land changes are likely to continue with rapid development of infrastructure, acquisition of land, quarry activities and increase in population. The upsurge of quarrying activities in the study area could be attributed to the rise in bare land space. Majority of urban changes occurred in close proximity to quarry operating sites, which poses serious environmental concerns.

3. What is the level of noise exposure and its health implications on the study area?

Blast noise generated from World Cool Quarry Limited indicated high levels of noise (i.e. 121.2 dBA and 115.7 dBA at distances of 203 m and 401 m away from the blast source respectively) above the maximum permissible limit of 115 dBA for annual period (Benin, 2007). Results from the exploratory blast measurement at the various locations revealed that blast noise levels decreased as distance increased away from the blast source. Residents living in close proximity to the blast source experienced higher impact of the noise-related effects as compared to those in remote areas.

Ambient noise level values recorded, also showed a decrease in levels away from the quarry site. However, an increase in noise level observed within the village centre at OS 3 (74.8 dBA) could be attributed to human activities and vehicular movements. Generally, these ambient noise values exceeded the maximum permissible level set by EPA of Ghana as shown in Appendix A.

As reviewed earlier in this study, blast noise exposure results in annoyance, headaches, cardiovascular effects, Tinnitus and sleep disturbance, which impair the quality of life of residents living in communities within the study area.

4. What is the relationship between blast noise measurements and social survey results?

There is a strong association between blast noise measurements and social survey results. Correlation coefficient (r) of 0.82 indicates a strong association between blast noise measurements and noise related effects. Hearing impairments and other related ailments mentioned in this study could be attributed to the continuous exposure of these level of noise to workers and inhabitants who live in close proximity to the quarry sites for a long time (enHealth Council, 2004).

5.2 Recommendations

1. Existing and future quarry companies within the study area should consider a 1000 meter buffer zone around quarry sites to fend off future residents from occupying these places. Community buildings that already fall within this zone should be evaluated and compensated in order to save residents from adverse effects of blast noise.
2. Communities in close proximity to a quarry site should inculcate the habit of tree planting around their houses to provide some amount of noise absorption.
3. Well planned blasting schedules must be used to notify residents before blasting activities take place. This will enable inhabitants to plan effectively against fly rocks and excessive pain from blast noise towards future blasts.
4. Environmental regulations and laws must be enforced by government agencies, local communities and non-governmental organizations or pressure groups for protection

and preservation of the environment. The monitoring agencies should be equipped with the necessary logistics for effective enforcement.

Further research should be done on the quantitative analysis of environmental impact of water and dust pollution within the study area. Exploratory blast and ambient measurements should be performed at other quarry companies in the study area.

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APPENDICES

APPENDIX A – EPA of Ghana Ambient Noise Level Standards

ZONE	DESCRIPTION OF AREA OF NOISE RECEPTION	PERMISSIBLE NOISE LEVEL IN dBA	
		DAY 06:00 - 22:00	NIGHT 22:00-06:00
A	Residential areas with low or infrequent transportation	55	48
B1	Educational (school) and health (hospital, clinic) facilities	55	50
B2	Areas with some commercial or light industry	60	55
C1	Areas with some light industry, places of entertainment or public assembly, and places of worship located in this zone	65	60
C2	Predominantly commercial areas	75	65
D	Light industrial areas	70	50
E	Predominantly heavy industrial areas	70	70

APPENDICE B – Questionnaire for Respondents

COLLEGE OF ENGINEERING – KNUST

Department of Materials Engineering

ENVIRONMENTAL IMPLICATIONS OF LAND USE LAND COVER CHANGE OF BUOHO TOWNSHIP AND ITS SURROUNDING COMMUNTIES.

Questionnaire for Inhabitants

Name of Inhabitant…………………….Location/Zone………………..Date………………

Please answer the following questions and tick the appropriate answer or fill in the blank spaces provided.

SECTION A

1. Gender

   Male ☐ Female ☐

2. Age

   20-29 ☐ 30-39 ☐ 40-49 ☐ 50-59 ☐ 60+

3. How long have you stayed in this area?

   <5 Years ☐ 5-10 Years ☐ 11-20 ☐ >20 Years ☐

SECTION B

4. Do you experience noise pollution?

   Yes ☐ No ☐

5. How often do you experience noise related ailments?

Always ☐ Occasionally ☐ Rarely ☐

6. What kind of ailment are you suffering from as result of the Noise Pollution?

Annoyance?
Noise Effect Rating

Strongly Agree (SA), Agree (A), Disagree (D), Strongly Disagree (SD)

SA ☐ A ☐ D ☐ SD ☐

Headache

SA ☐ A ☐ D ☐ SD ☐

Tinnitus

SA ☐ A ☐ D ☐ SD ☐

Sleep Disorder (*Sleeplessness*)

SA ☐ A ☐ D ☐ SD ☐

Cardiovascular Effect

SA ☐ A ☐ D ☐ SD ☐

7. Have you reported your grievances to the appropriate authorities?

   Yes ☐ No ☐

8. Do you want noise pollution from quarry companies to be controlled??

   Yes ☐ No ☐

APPENDICE C1 - Picture Showing Dust and Gas Emissions after Blasting

APPENDICE C2 – Charging of Drill Holes for blasting at World Cool Limited