SPATIAL ANALYSIS OF HUMAN ACTIVITIES IN AND AROUND PROTECTED AREAS: A CASE STUDY OF KAKUM CONSERVATION AREA (KCA), GHANA

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March, 2011

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Enschede, The Netherlands, March, 2011

Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente and the Faculty of Renewable Natural Resources of the Kwame Nkrumah University of Science and Technology in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation.
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I certify that although I may have conferred with other people in the preparation of this work, and drawn upon a range of sources cited in this study, the content of this thesis is my personal work.
Signed………………………………………………

DISCLAIMER

This document describes work undertaken as part of a programme of study at the Faculty of Geo-Information Science and Earth Observation of the University of Twente and the Faculty of Renewable Natural Resources of the Kwame Nkrumah University of Science and Technology. All views and opinions expressed therein remain the sole responsibility of the author, and do not necessarily represent those of the Faculties.

DEDICATION

Thesis dedicated to my two kids, Ernestina Mabeffam Binlinla and Timothy Betagman Binlinla. I say thank you for your endurance and prayers, and may the fear of God Most High and the wisdom that goes with it continue to be your aspirations on earth!

Proverbs 1:7, 9:1

ABSTRACT

The research aimed at investigating effects of human activities around 5km belt of the land adjoining Kakum Conservation Area (KCA) on the ecological functions and conservation of the protected area, as well as effects of KCA on local livelihood. Supervised classification of multi-spectral ASTER 2007 imagery was the main method used to determine land-use/land cover types in the study area. Questionnaire surveys, group discussions and key informant interviews were also conducted among 120 respondents from 40 sample communities. The study showed that growth rates in human population on the fringes of KCA went up by 0.8% after its establishment in 1991. Classification of the ASTER imagery provided a description of the dominant human activities around KCA. Five main land-use/cover types were identified; forest, mixed crops, oil palm plantation, cocoa and built-up/bare with a classification accuracy of 83.53%. Forest as a land-use/cover type refers to the landscape within the borders of KCA with the rest four being the land-use/cover types on the fringes of the PA. Instances of disturbed spots and other illegal activities were identified within KCA through the classified ASTER imagery and along transects respectively. It was found that there is a negative correlation between illegal activities and mean distance of communities from KCA. However regression analysis further showed that distance of communities from the PA was only 20% responsible for the variance in illegal activities in the PA (the rest 80% could be attributed to other unexplained variables). Correlation analysis further showed a positive but insignificant relationship between the size of population in communities and illegal activities in KCA with regression analysis showing that population size was only 4% responsible for the variance in illegal activities in the PA. Therefore mean distance of fringe communities from KCA was found to be more accountable for the occurrence of illegal human activities in KCA than the size of population in fringe communities, although distance was only 20% responsible. These results are somehow different from findings that were reported from similar studies that illegal activities in PAs are proportional to human densities in fringe communities. Eventually increased growth in human populations on the fringes of KCA has resulted in adverse effects on ecological processes in and around the PA through habitat conversion and human encroachments. On the other hand establishment of KCA has resulted in adverse effects on local communities through loss of livelihood because of inaccessible forest products and raiding of crops on adjacent farms by wildlife from the PA. In the end these effects generate community/park conflicts that further make KCA highly unsustainable biodiversity conservation area.
Keywords: Human activities, spatial analysis, protected area, conservation, livelihood.

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LIST OF ACRONYMS AND ABBREVIATIONS

ASTER	Advanced Space-borne Thermal Emission and Reflection Radiometer
CDB	Convention on Biological Diversity
ERDAS	Earth Resource Data Analysis System
GSS	Ghana Statistical Services
ICDPs	Integrated Conservation and Development Projects
IIED	International Institute for Environment and Development
IPCC	Inter Governmental Panel on Climate Change
ISSER	Institute of Statistical, Social and Economic Research
IUCN	International Union for Conservation of Nature
KCA	Kakum Conservation Area
MA	Millennium Ecosystem Assessment
MIKE	Monitoring Illegal Killing of Elephants
MDGs	Millennium Development Goals
NTFPs	Non-timber forest products
PACC	Programme Afrique Centrale et Occidentale
PA	Protected Area
REDD	Reduced Emission from Deforestation and Degradation
SPSS	Statistical Package for Social Science
UNEP	United Nations Environment Programme
UNCED	United Nations Conference on Environment and Development
WCNPPA	World Congress on National Parks and Protected Areas
WCMC	World Conservation and Monitoring Center
WWF	World Wide Fund for Nature
ZOI	Zone of Interaction

1. INTRODUCTION

1.1. Background

Tropical landscapes are undergoing rapid anthropogenic changes, particularly changes involving losses of forest, with general consequences for climate in the context of targets to Reduced Emissions from Deforestation and Degradation (REDD), biological diversity and maintenance of ecosystem services(Kufuor 2004; Guild *et al.,* 2004; Lauren *et al.,* 2008). Globally, rainforest cover is estimated to be reducing by about 0.8% per year (Gunatileke & Chakravorty 2003; Primack & Corlett, 2005). In the course of the last 8,000 years, the earth's tropical forest cover is said to have reduced by almost half from 62 million km² to 33 million km² with most of the lost occurring in the last three decades (Achard *et al.,* 2002). One major strategy adopted globally to stem the decline in tropical forest is the establishment of a network of Protected Areas (PAs) (Myers *et al.* 2000; Lawton, 2001). The International Union for Conservation of Nature (IUCN) defines a PA as a geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature, with associated ecosystem services and cultural values (Gaston *et al.*, 2008; Chape *et al.*, 2008). In this regard Margules and Pressey (2000) remarked that the basic role of a PA is to separate elements of biodiversity from processes that threaten their existence in the wild. The IUCN in 1978 classified the world's PAs into ten categories based on their management objectives. The categories were reduced to eight in 1984 and further reduced to six in 1994 as approved at the 4th World Congress on National Parks and Protected Areas (WCNPPA). The six categorisations are presented below (WCMC, 2008):

i. a. **Strict Nature Reserve/Scientific Reserve:** Protected Area managed mainly for science.
   b. **Wildness Area:** Protected Area managed mainly for wildness protection.
ii. **National Park:** Managed mainly for ecosystem protection and recreation.
iii. **National Monument:** Managed mainly for conservation of specific natural features.
iv. **Managed Nature Reserve/Wildlife Sanctuary:** Habitat/species management area, managed mainly for conservation through management interventions.
v. **Protected Landscape:** Managed mainly for landscape/seascape conservation or recreation.
vi. **Resource Reserve:** Resource protected area, managed mainly for sustainable use of natural resources.

The world's 100,000 PAs at present cover over 12% of the earth's land surface, and are known to be the greatest strongholds of biodiversity and landscape conservation (Chape *et al.,* 2008). The establishment of PAs have therefore assumed high priority as the impact of modern industrial society and its expanding demands for resources continues to spread even into the remotest parts of the world (Margules & Pressey, 2000; Chape *et al.,* 2008). The World Conservation Monitoring Centre (WCMC, 2008) opined that the establishment of a network of PAs have assumed growing importance because PAs among others:

- safeguard many of the world's outstanding areas of living richness, natural beauty and cultural significance.

- help to maintain the diversity of ecosystems, species, genetic varieties and ecological processes which are vital for the support of all forms of life on earth, and for the improvement of socioeconomic conditions of humans.
- protect genetic varieties and species which are vital in meeting human needs, for instance in agriculture and medicine, and are the basis for human socio-cultural adaptation in an uncertain and changing world.
- have significant scientific, educational, cultural, recreational and spiritual values.
- provide major direct and indirect benefits to local and national economies at large.

According to Abuzinada (2003) the fact that virtually all nations in the world have established a network of PAs is an indication of the commitment of governments' in ensuring that generations pass on to future generations a world which is as biologically diverse and productive as the one being enjoyed by present generations. Unfortunately these natural assets are under increasing pressure and threats mainly because of expansion in human demands upon the environment, demands that have their origins in exponential population growth and excessive consumptions (Wittemyer *et al.,* 2008; De Fries *et al.,* 2009; Gaston *et al.,* 2008).

1.1.1. Pressure and threats to protected areas in Ghana

PAs in Ghana are faced with threats that militate against their effective functioning. A recent evaluation of management effectiveness of PA network in the country by the IUCN identified land conversion on the edge of PAs due to agriculture, human encroachment and bush fires among the major pressure and threats that confront the nation's PAs (IUCN/PACO 2010). As forest resources get depleted people get attracted to landscapes that border PAs because of the ecosystem services these landscapes continue to offer (Scherl *et al.*, 2004; Alo & Pontius, 2008). The net effect is that resources within PAs are put under threats from human encroachments that results from accelerated population growth around the PAs (Jachmann, 2008). For this reason illegal gathering of products from PAs has become a major source of regular conflicts between locals and PA managers in the country, resulting from conflict of interest over resource utilization. Conversion of landscapes around PAs to agriculture is reported to be on the increase in the forest belt because forests provide favourable climates and ecological conditions required for the production of cocoa *(Theobroma cacao)* which is the country's main cash crop. This situation encourages human encroachment in PAs that are found in the country's forest zones and thereby reduces the effective size of habitats around them. In the end, accelerated growth rates in populations around PAs impact their long term sustainability and success at conserving biodiversity in the country, as edge effects and isolation of PAs get intensified (Wittemyer *et al.,* 2008).

1.1.2. Historical perspective of protected areas in Ghana

The principle of PA system is not entirely unknown to the Ghanaian society (Wiggins *et al.,* 2004). Historically Ghanaians have had traditional laws that tended to conserve the environment and natural resources (DGW-IUCN, 1996). Even though population levels were low with hunting and farming equipment at the basic level, traditional laws and practices on conservation were in place (Ghana Gazette, 2006; Hawthorne & Abu-Juam, 1995). As far back as in pre-colonial days' traditional laws and conservation practices were established as part of the fabric of society that helped in biodiversity conservation. Such indigenous laws arose from the belief in totems through which people had a mystic union with plants/animals or natural objects. These practices tended to protect resources in 3 main ways; by protecting specific ecosystems, by protecting particular flora and fauna species and by regulating the exploitation of natural resources through the imposition of taboo days and "closed periods" (DGW-IUCN, 1996). The advent of colonial rule in the country however saw the introduction of formal laws to govern reserves. By the time of independence in 1957 as many as 185 forest reserves covering an area of 15,769 km² of the forest estate in Ghana had been established under the then Forestry Department (DGW-IUCN, 1996). Soon after independence the Forestry Department assumed responsibility for the enforcement of Game Preservation Ordinance which subsequently led to the establishment of Ghana's first Game Department (DGW-IUCN, 1996). A new Act, the "Wild Animals Preservation Act, (43) of 1961," was then formulated by the state to provide the legislative authority and guidelines for the conservation of wildlife and establishment of PAs in the country (DGW-IUCN, 1996).

1.1.3. Present system of protected areas in Ghana

PAs in Ghana presently fall under two broad categories: forest reserves that are estimated to cover 11% of the nation and wildlife PAs, which is the focus of this research cover about 6.2% of the country's terrestrial surface. The establishment of PAs and changes to existing ones require Ministerial and Parliamentary approval, upon which boundaries are published in the Government Gazette (IUCN/PACO, 2010). The Wildlife Division of the Forestry Commission, under the Ministry of Lands and Natural Resources in Ghana is responsible for administration and management of 21 wildlife PA network in the country. These include 7 National Parks, 6 Resource Reserves, 2 Wildlife Sanctuaries, 1 Strict Nature Reserve and 5 Coastal Wetlands/Ramsar Sites (See appendix A.1 for PA categories in Ghana). The PA network is a fair representation of the ecological zones of the country, classified in accordance with management objective of the area in question, and as well reflecting the IUCN system of PA categorisation. Most of the wildlife reserves within the forest zone were, however, former forest reserves or parts of forest reserves (DGW-IUCN, 1996). A total of 1,151,110 ha or 4.8% of the country's PAs are located in the woodland savannah to the north of the country whereas 122,880 ha or 0.6% of the PAs are situated in the rainforest zone, mainly in the central and southern part of the country. Coastal wetlands/Ramsar sites constitute 159,950 ha or 0.7% and are located along the coastal belt of the country. The 21 PA network constitute 1,432,940 ha or 6.2% of the country. A major change in the approach to biodiversity conservation in the country was adopted in the form of the Forest and Wildlife Policy of 1994 (Ghana Gazette, 2006; MLF, 1994). The aim of the policy was to "conserve and sustainably develop the nation's forest and wildlife resources for maintenance of environmental quality and perpetual flow of optimum benefits to all segments of society" (DGW-IUCN, 1996).

1.2. Research problem and justification

Ghana's total land area is estimated to be 23.9 million ha (Amanor 1999; Kotey *et al.,* 1998). About 15% of the land cover is under protection in the form of wildlife and forest reserves (Agyarko, 2001; Kotey *et al.,* 1998). Among the challenges currently confronting the country are unrestrained exploitation of forest resources, suburban sprawl and increasingly fragmented natural habitats (Kotey *et al.,* 1998). The country's forested estates at the turn of the 20th century covered around 8.2 million ha of land (IIED, 2008). This cover sharply reduced to 2.1 million ha by the late 1980s, and 1.6 million ha by 2007(IIED, 2008). Just as any other developing country, forest resources play important roles in the economy of Ghana (Kufuor, 2004; Ghana Gazette, 2006). Food, timber, fuel-wood, medicinal plants and building materials are some of the many ecosystem services derived from the forest, estimated to contribute about 43% of Gross Domestic Product and 40% of export earnings in Ghana (Agyarko, 2001). As a result the country's landscape has been categorized into various land-use types in order to provide the needed goods and services for human satisfaction. They include small and large scale farms, PA and nature reserves, urbanization, and tree plantations (Affum-Baffoe, 2001). However landscapes that fringe PAs experience high densities of human populations often resulting in conflict of interest between PA managers and locals over natural resource utilization. PAs and their adjoining landscapes have the tendency to attract people because they are perceived to abound in vast ecosystem services in comparison to unprotected areas (Alo & Pontius, 2008). This situation reduces effective size of habitats around PAs in the country and renders them vulnerable to human encroachment (IUCN/PACO, 2010). As a consequence PA managers are confronted with increasingly complex and challenging issues that require understanding of the status and trends of landscapes that border PAs. This will assist in adopting effective conservation and management strategies in order to achieve the objectives for which PAs were established. In particular as human activities isolates PAs from the adjoining landscapes, the challenge is to identify management strategies that maintain ecological functions within the PA network while, minimizing restrictions on land-use around. Consequently monitoring and evaluation of human activities in and around PAs with Geographic Information System, Remote Sensing, demographic and related spatial data have become useful requirements in the country.

1.3. Research objective

The research has been decomposed into main and specific objectives as indicated below:

1.3.1. Main objective

The main objective of the research was to investigate the effects of human activities on landscapes around Kakum Conservation Area (KCA) on the ecological functions and conservation of KCA, as well as the effects of KCA on local livelihood.

1.3.2. Specific objectives

The following specific objectives were set in order to achieve the main objective:

- To establish the correlation between proximity of human activities to KCA and the level of encroachment in KCA.
- To assess the population growth trends in communities around KCA
- To identify and describe segments of the bordering landscape that have the most influence on KCA.
- To map the spatial distribution of human activities in and around KCA.
- To assess effects of the existence of KCA on livelihood of local communities.

1.4. Research questions

In order to achieve the specific objectives the research sought to answer the following questions:

- What are the existing land-use/cover types around KCA?
- What are the demographic characteristics of the study area?
- How do the land-use types affect ecological functions and biodiversity conservation in KCA?
- What is the relationship between mean distance of communities and illegal activities in KCA?
- Can human population around KCA serve as a basis for determining level of encroachment in KCA?
- What are the effects of topography in KCA on illegal activities in KCA?
- What are the effects of establishment of KCA on local livelihoods?

1.5. Research hypothesis

The following hypothesis was formulated for this research:

- There is a correlation between proximity of human activities to KCA and encroachment in KCA.

1.6. Research outcome

The outcome of this research is expected to contribute to knowledge in the following ways:

- Understand the ecological and socioeconomic settings in and around PAs.
- Produce a distribution map of human encroachment into Kakum Conservation Area.
- Understand the complex and dynamic conflicts of interest that have arisen between PA management and local livelihood.
- Serve as input in developing livelihood support schemes that will satisfy local resource needs with minimum harm on ecological functions in PAs.
- Serve as a reference material for the development of land use policies around PAs and a guide to Wildlife Division of the Forestry Commission in Ghana.

1.7. Conceptual framework

Figure 1.1 illustrates the research concept based on the ideas of De-Fries *et al.,* (2009). The concept originated from the buffer zones concept previously applied around some PAs (De-Fries *et al.,* 2009; Freeman *et al.,* 2007). The idea in the conceptual framework is that the first step towards maintaining integrity of a PA in varied land-use/cover context is to designate a Zone of Interaction (ZOI) around. The ZOI delineates the neighbouring landscapes and the extent of ecological and socioeconomic interactions between a PA and its surroundings. In the view of Hansen and De-Fries (2007) designation of a ZOI around a PA is depended on mechanisms through which land-use changes outside of a PA modifies and adversely affects ecological functions within the PA.

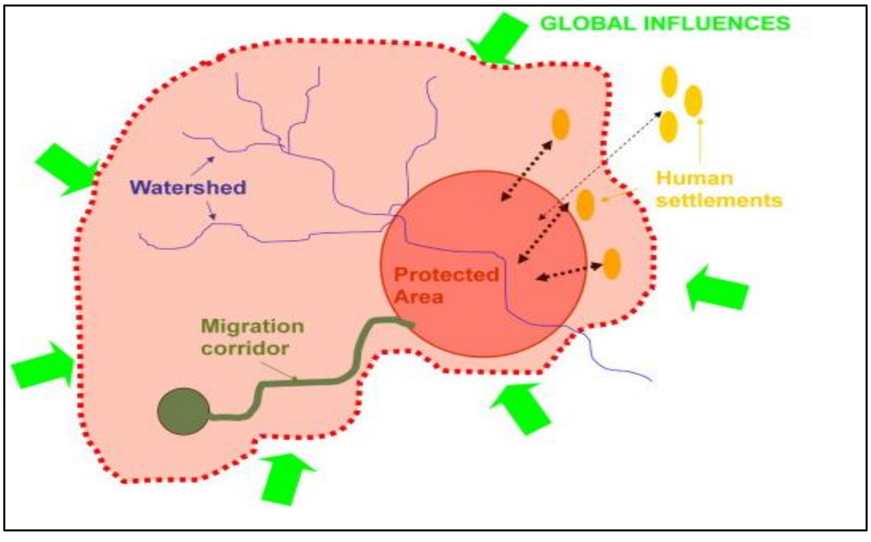

Figure 1.1: Conceptual framework. Source: De-Fries *et al.,* 2009).

The concept of a ZOI is comparable to the situation in KCA based on increased human populations, existence of communities and agricultural activities in the midst of ecological processes within and around the PA. In figure 1.1 the red dotted line indicates a ZOI based on hydrological, ecological and socioeconomic interactions between KCA and its surrounding landscapes. The thick dotted black arrows signify strong interactions of the PA with settlements that are closer to the boundary of KCA. These arrows indicate interactions between the PA and its surroundings in the form of agricultural activities close to the PA boundary and losses suffered by farmers through crop raiding by wildlife migrating from the PA on one hand, and human encroachment from local communities into KCA on the other hand. The thin dotted black arrows represents weaker socioeconomic and ecological interactions with communities that are comparatively farther from the PA and as such fall outside of the ZOI. It is further indicated that these last group of communities tend to have less interactions with the PA by virtue of their distances, and therefore exert less pressure on ecological functions and processes in KCA. The ZOI is also influenced by regional and global factors such as climate change as indicated with the green arrows. This research therefore aims at analyzing population growth and human activities around KCA and the levels of interactions and successive effects on ecological processes in KCA and on local livelihood.

1.8. Research process

Figure 1.2 describes processes involved in the research from review of literature through problem and objectives formulation, data collection and analyses to conclusion.

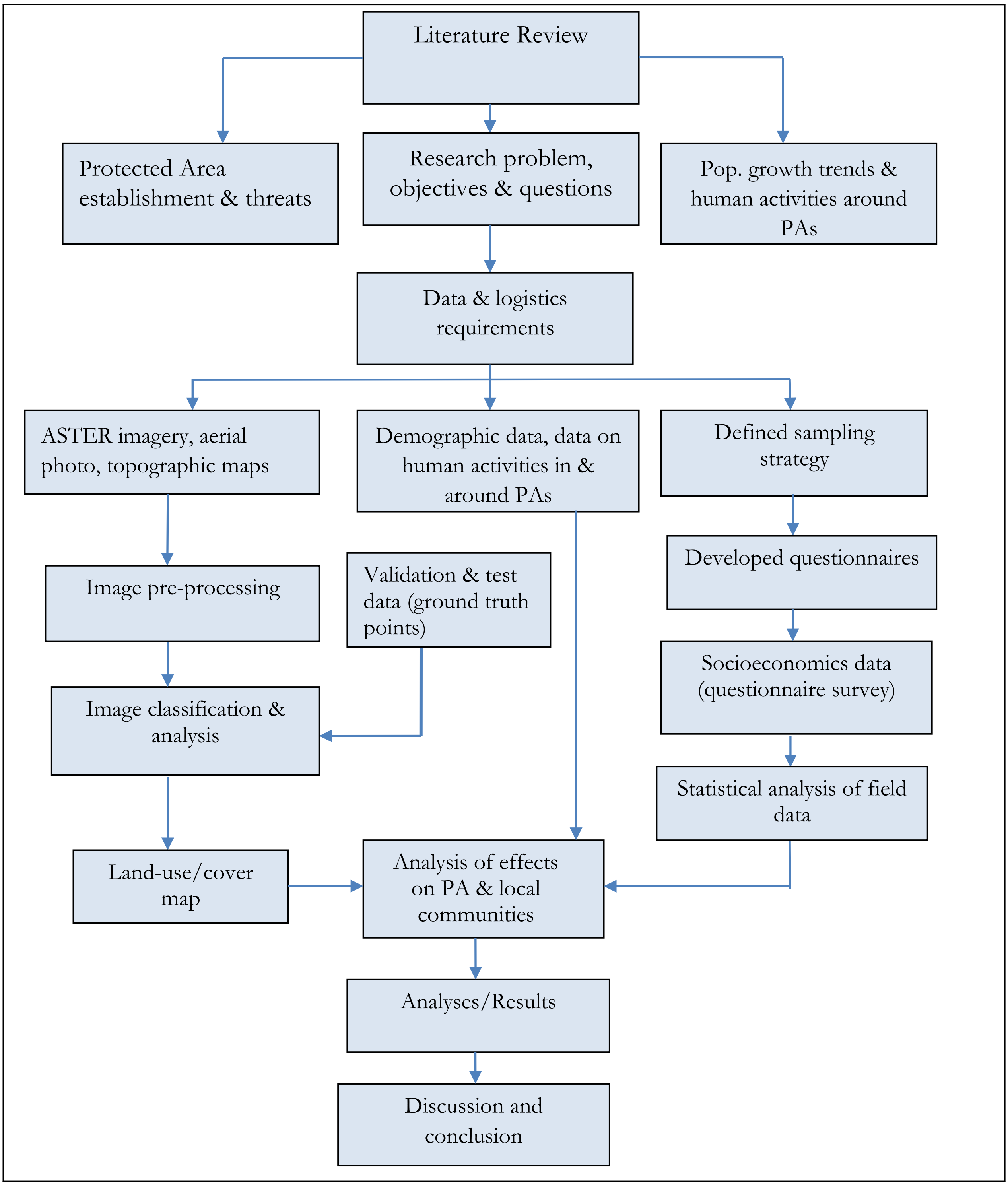

Figure 1.2: Flowchart of the research process.

2. CONCEPTS AND DEFINITIONS

2.1. Biological diversity

Biological diversity or biodiversity for short encompasses the variability among living organisms from all sources including *inter alia,* terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems (CBD, 2000). Biodiversity can be divided into three hierarchical categories; genetic diversity, genetic variations within a population and ecosystem diversity (Slootweg, 2006). Biodiversity in the world is said to be lost through habitat loss and fragmentation, overexploitation, introduced species, chemical pollution, climate change and agricultural expansion among others (Slootweg, 2006). Since biodiversity is closely intertwined with human needs, its conservation should rightfully be considered as an element of national security (UNEP, 2004; Wood & Stedman-Edwards, 2000).

2.1.1. Biodiversity conservation

The IUCN defines biodiversity conservation as the management of human use of the biosphere in such a way that it may yield the greatest sustainable benefits to present generations while maintaining its potential to meet the needs and aspirations of future generations (McNeely *et al.,* 1990; Voinov *et al.,* 1999). The need to conserve the earth's biodiversity has been growing steadily since the first "Earth Summit" in Rio de Janeiro in 1992 convened by the United Nations Conference on Environment and Development (UNCED) (Margules & Pressey, 2000). The summit was an attempt to address the urgent problems of environmental protection and socioeconomic development in the world. The Convention on Biological Diversity (CBD) was a groundbreaking initiative adopted by the vast majority of the world's governments at the summit (Norton, 1999). Among the 3 main goals established by the Convention was the conservation of biodiversity. Various researchers have acknowledged decline in the world's biodiversity as a result of direct and indirect consequences of use and misuse of the environment by humans. Consequently this research intends to explore the extent to which land conversions through various human activities, have impacted biodiversity on landscapes that surround KCA, and to a large extent on biological processes within KCA, a PA that has been classified among the world's biodiversity hotspots (Myer *et al.,* 2000).

2.2. Forest and livelihood

Livelihoods comprise the capabilities, assets, resources, claims and activities required for a means of survival (McSweeney, 2004). The livelihood of people living mostly in rural areas in the tropics depends to a large extent, on forest resources in terms of materials necessary for daily life. A World Bank study emphasized the direct link between forests and poverty, "as over 1.6 billion people living in extreme poverty depend on forests for some part of their livelihoods" (WORLD BANK, 2004; WRI, 2005). Based on their research Shackleton *et al.* (2007) suggested at least 3 direct household benefits of forest resources: (1) supply of basic needs such as food, fuel-wood, edible fruits, building materials, medicinal plants and weaving fibres, (2) when forests yield products that households do not need to purchase with cash, forest use becomes a way to save scarce cash resources, and (3) forests play important "safety net" functions for poorer families and communities in lean or troubled times, a role that was also acknowledged by (McSweeney, 2004). Safety-net functions of forests resources generally occur through the use of forest resources that one does not normally use, or increasing consumption of forest resources already used in order to substitute purchased commodities and selling forest resources in local/regional markets to generate cash temporarily.

Most rural households in Ghana depend on the forest and its products for their livelihoods and daily subsistence (Amanor, 1999). Aside from conversion largely to agriculture one other major use of forest is through gathering of Non-Timber Forest Products (NTFPs). There is a wide variety of NTFPs that are used for food, wood-fuel, medicines, forage, fibre that have valuable chemical components or that are used for ritual purposes in Ghana. The majority of NTFPs are consumed directly by collectors and their families whereas some serve as important mainstays in the household economy. Others are used infrequently, but can be critically important as sources of food when other sources are unavailable. Such emergency foods can sometimes actually make a difference between life and death (Amanor, 1999). Consequently this research intends to find out the extent to which establishment of KCA as forest conservation area, has affected livelihood needs of local communities.

2.3. Causes of deforestation and degradation

Forests are lost and degraded mainly because people modify forested landscapes in a range of ways to derive socioeconomic and livelihood needs (Carpenter *et al.,* 2006). These include agricultural conversion, wood and NTFPs extraction and infrastructure extension. Factors that cause deforestation and degradation are termed drivers of deforestation (Rademakers *et al.,* 2010). The Millennium Ecosystem Assessment (MA) defined a driver as human induced factor that directly or indirectly cause a change in an ecosystem (Carpenter *et al.,* 2006; MA, 2005). According to Rademakers *et al* (2010) there are two kinds of drivers of deforestation; direct and indirect drivers. Direct drivers of deforestation are those that directly lead to forest decline. For instance excessive logging or forest conversion to agriculture fields, whereas indirect drivers' result from a remote causes such as increase in human population. Deforestation in Ghana is caused by both direct and indirect drivers and includes resource extraction, infrastructure development, logging and conversion to agriculture fields, indirectly resulting from demographic changes (Kufuor, 2004; Agyarko, 2001). Similarly direct causes of deforestation in the case of KCA are mainly clearing for agriculture, settlements and illegal use of resources within the PA, with increased growth rate in human population around the PA as an indirect cause.

2.3.1. Illegal use of forest resources

The use of forest resource can be in the form of extractive, in which case products are harvested to meet livelihood needs, or non-extractive as in recreational services such as hiking and wildlife viewing within a PA. Extractive activities are known to result in deforestation as they ultimately change the trajectory of ecological successions (Okello *et al.,* 2008). Illegal activities for instance, alter dominant flora and fauna communities within entire ecosystems (Gavin, 2007). Holmern *et al* (2007) defined illegal resource use as commercial and subsistence use of a resource in violation of regulations. Illegal use of forest resources in the form of ecosystem services, within PAs have been identified as major threat to biodiversity globally (Okello *et al.,* 2008). The IUCN management categorization permits limited use of resources within less restrictive PAs. In that regard an illegal activity may be considered to entail violations of ownership rights, such as harvesting of resources from a PA without approved permit (Holmern *et al*., 2007). Other forms of illegal use of resources include violation of resource-use regulations, uses that are in excess of established limits and use of resources within areas that are strictly prohibited. An illegal activity in this research means extractive use of forest resources within KCA in violation of statutory regulations.

2.3.2. Cocoa as a major driver of deforestation

Agricultural production is found to be a major cause of deforestation in the world and a leading driver of biodiversity loss in the tropics (Primack & Corlett, 2005). In the same direction Mattison and Norris (2005) argued that the fate of biodiversity is intimately linked to the use of land for agricultural production. Quite recently, the impacts of some major agricultural crop commodities including cocoa (*Theobroma cacao*), coffee (*Coffea arabica*) and oil palm (*Elaeis guineensis*) on biodiversity have become a major issue of international conservation interest among researchers (Donald, 2004; Rice & Greenberg, 2000). Cocoa is among the world's most important agricultural exports and a major earner of foreign income for countries that dominate in its production (Primack & Corlett, 2005). The countries include Ghana, Côte d'Ivoire and Cameroun in West Africa. The crop is grown in lowland tropical forests, mainly in biodiversity hotspots (Myers *et al.,* 2000). About 60% of the world's cocoa is produced in West Africa including Ghana. The cocoa industry in Ghana forms an important component of the agricultural sector. Sales of cocoa beans have been one of the major foreign exchange earners to the economy of Ghana throughout the years. It is estimated that there are about 1,195,358 hectares of forest land under cocoa cultivation in the country, with about 445,145 farmers dependent on the crop for their livelihoods (Asante, 2005). As a result the crop has been identified as a major contributor to deforestation at the forest-agriculture interface in Ghana (Asase *et al.,* 2009). The government of Ghana has again prioritized cocoa as a major commodity crop and aimed at increasing its production from current levels of 745,000 metric tons to 1,000,000 metric tons by the end of 2010 (Asase *et al.,* 2009). There are six cocoa growing regions in Ghana namely: Ashanti, Brong-Ahafo, Eastern, Volta, Western, and the Central region where the study area, KCA is situated.

Since the gradual recovery of the cocoa sector during the late 1980s, cocoa frontier settlement in Ghana involved movements of people from areas with scanty patches of remaining tropical forest to regions that had and still has a much larger stock of tropical forest in the country (Kees Van & Vrieling, 2010). This scenario led to conversion of forest habitats to agriculture lands including landscapes that border forest PAs in the country. Figure 2.1 shows cocoa growing regions and population movements in Ghana.

Figure 2.1 shows forest zones, main population movements, and cocoa growing region in Ghana.

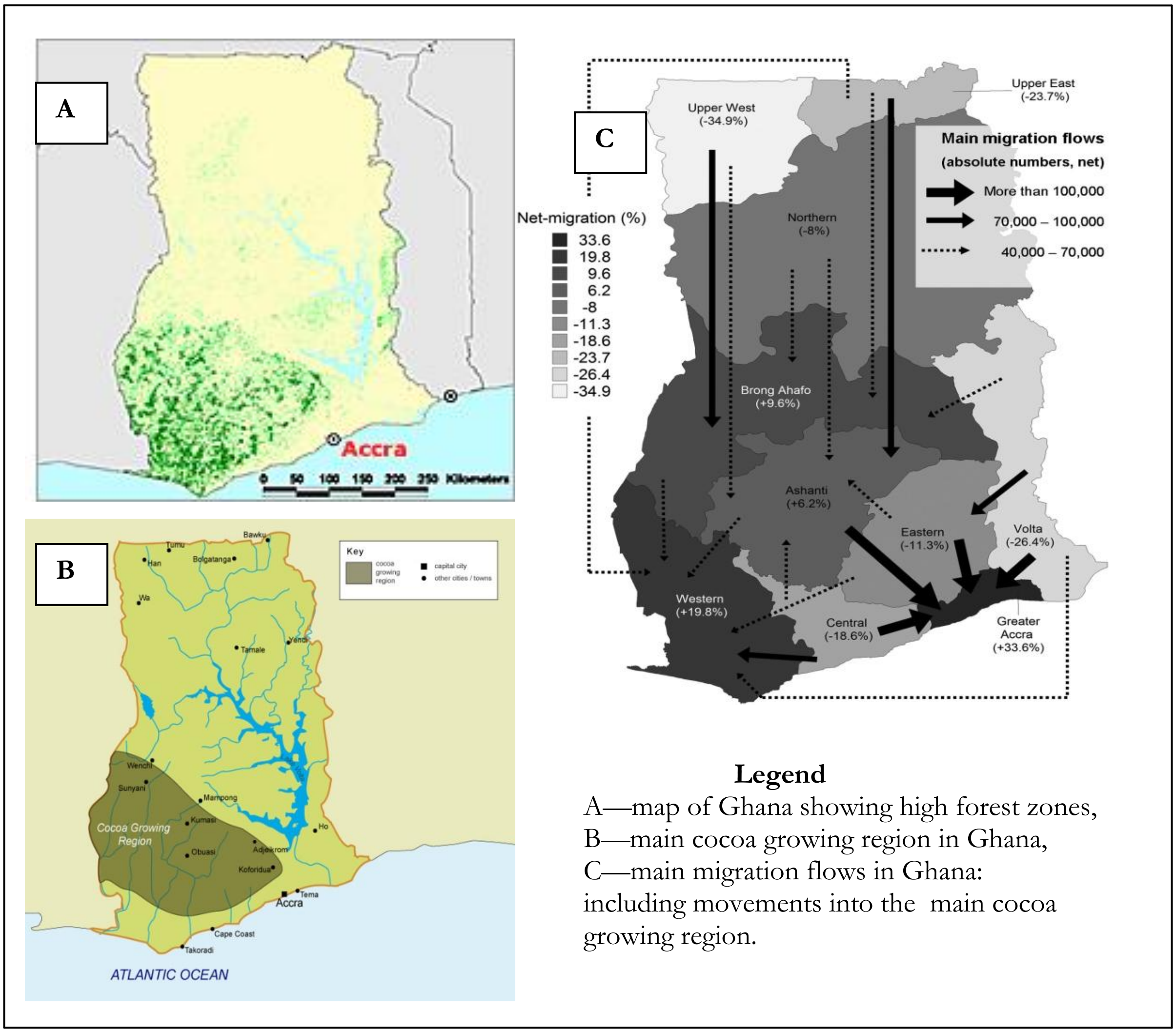

Figure 2.1: Forest zones, population movements and cocoa growing region in Ghana.

Source: (Kees Van &Vrieling, 2010; Ghana Gazzete, 2006; Kufuor, 2004).

2.4. Human population growth near protected areas

Human population growth, particularly in developing countries is recognised as a force behind environmental change (Escamilla *et al.,* 2000). Wittemyer *et al* (2008) revealed that landscapes that border PAs are beset with rapidly growing human populations. These landscapes are experiencing dynamic change in land-use and land-cover often associated with changes in demographic trends in the area (Goldman *et al.,* 2002; Voinov *et al.,* 2004). Chape *et al* (2008) remarked that many forest PAs in developing countries in reality serve as surrogate urban centres that attract human populations to their fringes mainly because of the comparatively abundant ecosystem services found in these areas. Wittemyer *et al* (2008) found average population growth rates on the borders of 306 PAs located in 45 countries in Africa and Latin America to be nearly double the average rural growth rates (Figure 2.2).

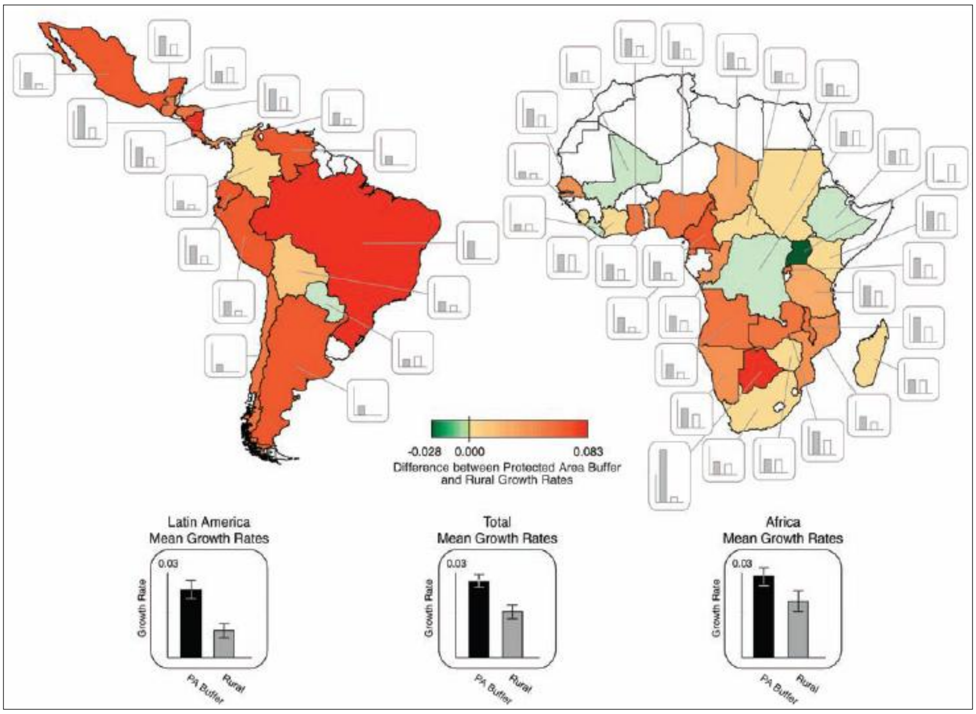

Figure 2.2: Comparison of population growth in rural areas and around PAs.

Source: (Wittemyer *et al.,* 2008).

These findings are enough evidence of the values that PAs have for local communities in terms of ecosystem services and livelihood satisfaction. At the same time however, the findings highlight a looming threat to PA effectiveness and biodiversity conservation in the tropics (Hansen & De-Fries, 2007). By encouraging population growth and accelerating the isolation of PAs from natural landscapes, the net impact of PAs on conserving biodiversity may be negligible (Mustard *et al.,* 2004; Newmark, 2008). These revelations are not different from what is experienced around KCA and similar PAs in Ghana. The luxuriant forest resources in and immediately around KCA have since its establishment attracted people from other regions of the country to its fringes largely engaged in agriculture. And so the research intends to study population growth trends in the study area and find out its impacts on the neighboring landscapes and on biological processes in KCA.

2.5. Emerging trends in protected area management

Human activities around PAs are intensifying world-wide where no one thought it would (Lawton, 2001). Trend that has emerged currently in PA management is the focus that these landscapes should be considered as a system. That is they should be considered as part of a larger network that is nested within the broader socioeconomic context, and at the same time forms a component of the related ecological landscapes (Margules & Pressey, 2000). This is because there is a growing realization that managing PAs in isolation from the main forces that shape the environment is no longer feasible in a rapidly changing world of increasing human populations, with its pressure on natural resources (Albers and Robinson, 2007; Phillips, 1998). Margules and Pressey (2000) therefore opined that PAs should be fashioned in such a way as to guarantee poverty eradication as well as ensuring environmental sustainability in countries were they are located. In that sense PAs will also be fulfilling the first and seventh goals (I & VII) as described in the Millennium Development Goals (MDGs). Accordingly, PAs have since been linked to national policies through national environmental action plans, national conservation and strategies for sustainable development and more recently to biodiversity action plans and strategies under the Convention on Biological Diversity (CBD) (Margules & Pressey, 2000). Response strategies in PA planning have included the need to provide for support zones to buffer them against excessive pressures beyond their boundaries and as well, provide a range of benefits toward local livelihood needs, a plan that gave way to the concept of Integrated Conservation and Development Projects (ICDPs) around some of the world's PAs (Dudley *et al.,* 2003).

3. MATERIALS AND METHODS

3.1. Study area description

The research was conducted in and around Kakum Conservation Area (KCA). It is a tropical rainforest PA situated in the southern part of Ghana. It comprises two contiguous reserves; Kakum National Park and the Assin Attandanso Resource Reserve, which was officially established in 1991 and managed as Kakum Conservation Area. Figure 3.1 shows a map of the study area made up of KCA and 5km buffer of the bordering landscape with inset ASTER bands 321 imagery. Portions of the ASTER imagery, marked in red on the map were however covered by clouds and could not be analyzed.

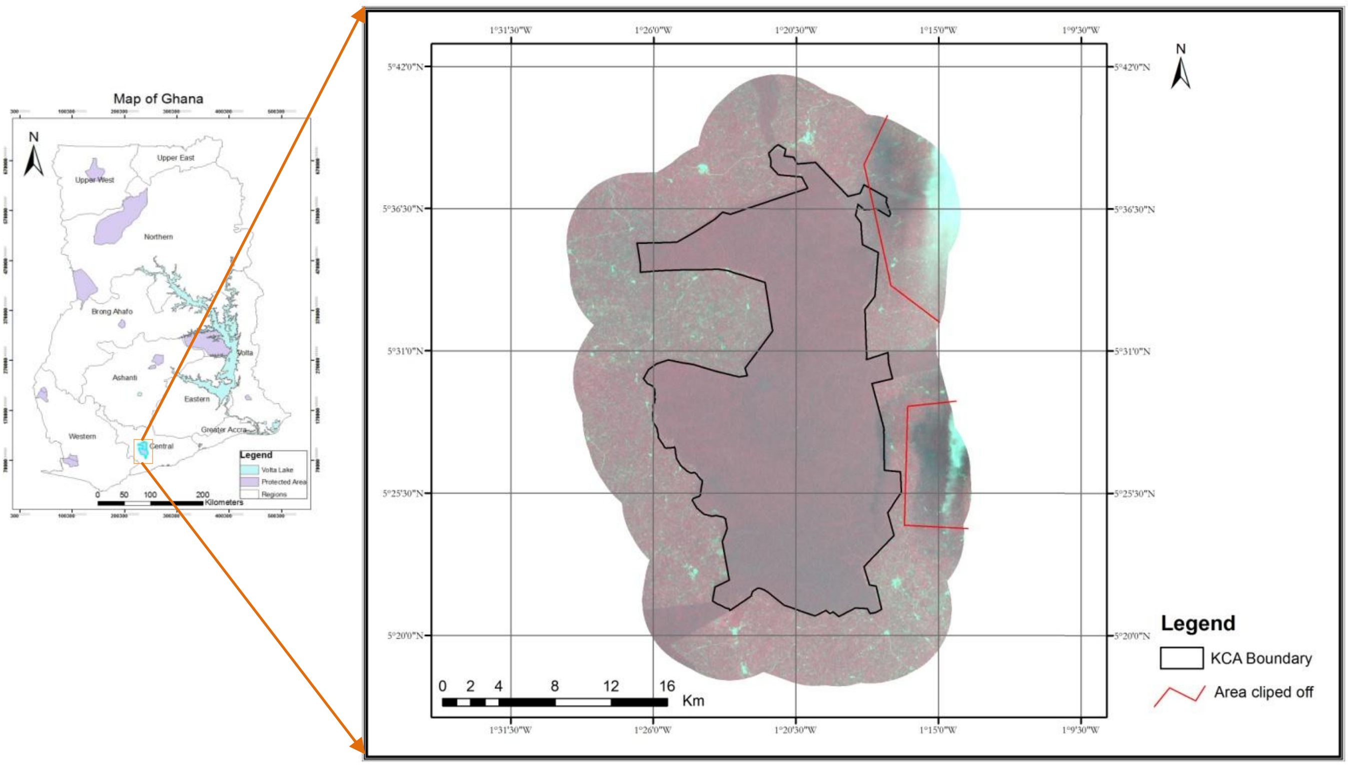

Figure 3.1: Study area: Kakum ConservationArea (KCA).

KCA covers a total area of 360 Km² and located between latitudes 5°20' and 5°40' N and longitudes -1°51' and -1°30' W (Hawthorne & Abu-Juam, 1995). The PA forms part of the Upper Guinean Forest in West Africa described among the world's biodiversity hotspots (Myers *et al.,* 2000). KCA experiences two-peak rainy seasons within a year; the peak rainfall months are from May—June and September—October (Figure 3.2). There is a dry season from December to February or sometimes March when many water-courses dry up in the forest. The average annual rainfall is between 1,500mm and 1,750mm. Average relative humidity is about 85% while average temperature ranges between 20.2°C and 31.6°C. These very favourable climatic conditions work as an additional attractor to further population growth in this area. In particular the two-peak rainy seasons coupled with relatively high temperatures affords two cropping seasons with considerable farm yields in a year quite different from other vegetation zones in the country.

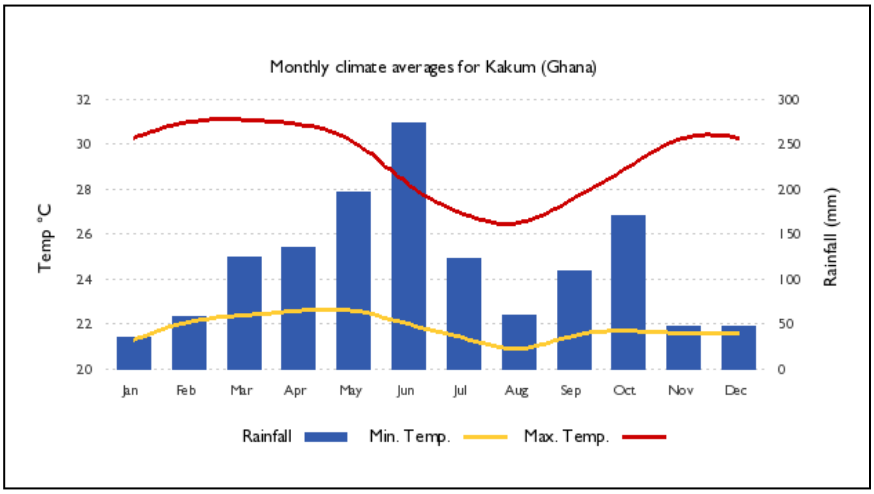

Figure 3.2: Average climate record of KCA

Source: Global Environmental Commission (GEC, 2010).

3.1.1. The environs of KCA

Traditionally the entire landscape that includes the two contiguous reserves belongs to Assin, Twifo Hemang, Denkyira and Abura-Asebu Kwaman-Kese states. Citizens of the various states who constitute the indigenes have since lived within the vicinity of the reserve, mainly involved in farming. The main crops include food-crops such as cassava *(Manihot esculenta),* plantain *(Musa sapientum)* and maize *(Zea mays)* with cocoa *(Theobroma cacao)* and quite recently oil palm *(Elaeis guineensis*) as the main cash crops grown. Besides agriculture the locals supplemented their livelihood needs with non-timber forest products (NTFPs) which they collected from the forest without restrictions. This situation continued until 1991 when KCA was established as a PA and so access to resources within the confines of KCA became restricted (Dickinson 1998; Eggert *et al.,* 2003). The locals however continued to engage in small scale cocoa farming and related agricultural activities on the fringing landscapes. Around the late 1980s onwards the cocoa industry in Ghana began to receive more political attention through the control of swollen shoot and black pod diseases, increased producer prices and incentives for cocoa production (Asase *et al.,* 2008; (Kees Van & Vrieling, 2010). These conditions facilitated movements of people from regions with small patches of remaining forests to regions with relatively large stock of forest with favourable ecological conditions for cocoa cultivation. Hence the landscape surrounding KCA experienced inflows of migrant cocoa farmers from other regions with its attendant agricultural pressure on the adjoining landscape as well as on the PA (Figure 3.3).

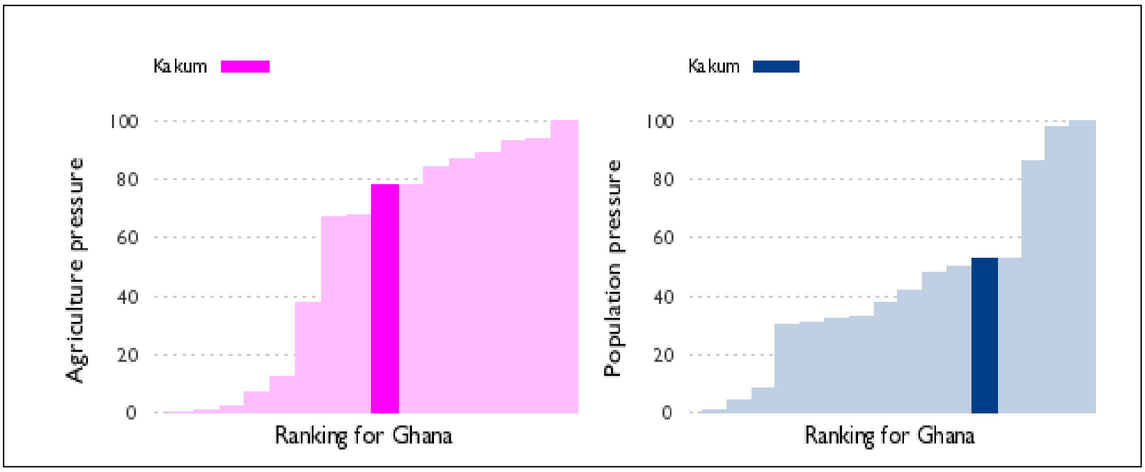

Figure 3.3: Levels of agriculture and human population pressure on KCA.

Source: Global Environmental Commission (GEC, 2010).

There were 52 major communities bordering KCA with estimated population of 37,000 in the mid-1990s (Agyare, 1995). Dickinson (1998) as well estimated about 1,000 farms within 5km belt of KCA. These figures may not reflect the current situation in the area as trends have since changed. Human populations have increased and new settlements emerged within the environs of KCA. Mainly because many more people have moved into the area to take advantage of favourable agricultural lands created as a result of protection of KCA (Barnes *et al.,* 2003). The study sampled 40 communities located within 5km buffer of the PA for analysis of demographic trends, human activities, and extent of impacts on ecological functions and processes within KCA. Communities within this range were sampled because this distance falls within a reasonable daily travel distance for a person on foot and also matches the unit of analysis in related studies (Wittemyer *et al.,* 2008).

3.2. Data sources

Both primary and secondary sources of data were used in this research. Secondary data was acquired from institutions whiles primary data was collected through field work (Table 3.1).

Table 3.1: Primary and secondary data used.

Data type	
Primary data	Secondary data
• Ground truth points • Illegal human activities (along transects in KCA) • Questionnaire surveys	• Multi-spectral satellite imagery (ASTER RGB bands 123 of 24th September 2007) • KCA boundary shapefile • Aerial photo (Google) of 2008 • 1:50,000 topographic maps (soft copy) • KCA management plan • Demographic data • Record of poacher arrest in KCA • Record of hunters' trail (within KCA) • Crop raiding report (2008)

3.3. Software and materials

Other materials used in this research include the following:
- Instruments used in support of field work are listed in Table 3.2.
- Software used for data analysis and thesis writing are listed in Table 3.3

Table 3.2: List of instruments used for field work.

Instruments	Purpose of usage
GPS Garmin(60cx)	Navigation & location of coordinate points
Suunto compass	Determining orientation in KCA
Field data sheets	Field data record

Table 3.3: List of software used in the research.

Software	Purpose of use
ArcGIS Desktop Version 9.3	GIS analysis of ASTER imagery
ERDAS imagine 9.2	Processing of ASTER imagery
Microsoft Excel	Statistical analyses
SPSS	
Microsoft Word 2007	Thesis write-up and editing
Microsoft EndnoteX4	
Microsoft Visio	
Adobe Acrobat Professional	

The methods used in the research have been described with a flowchart as indicated in figure 3.4.

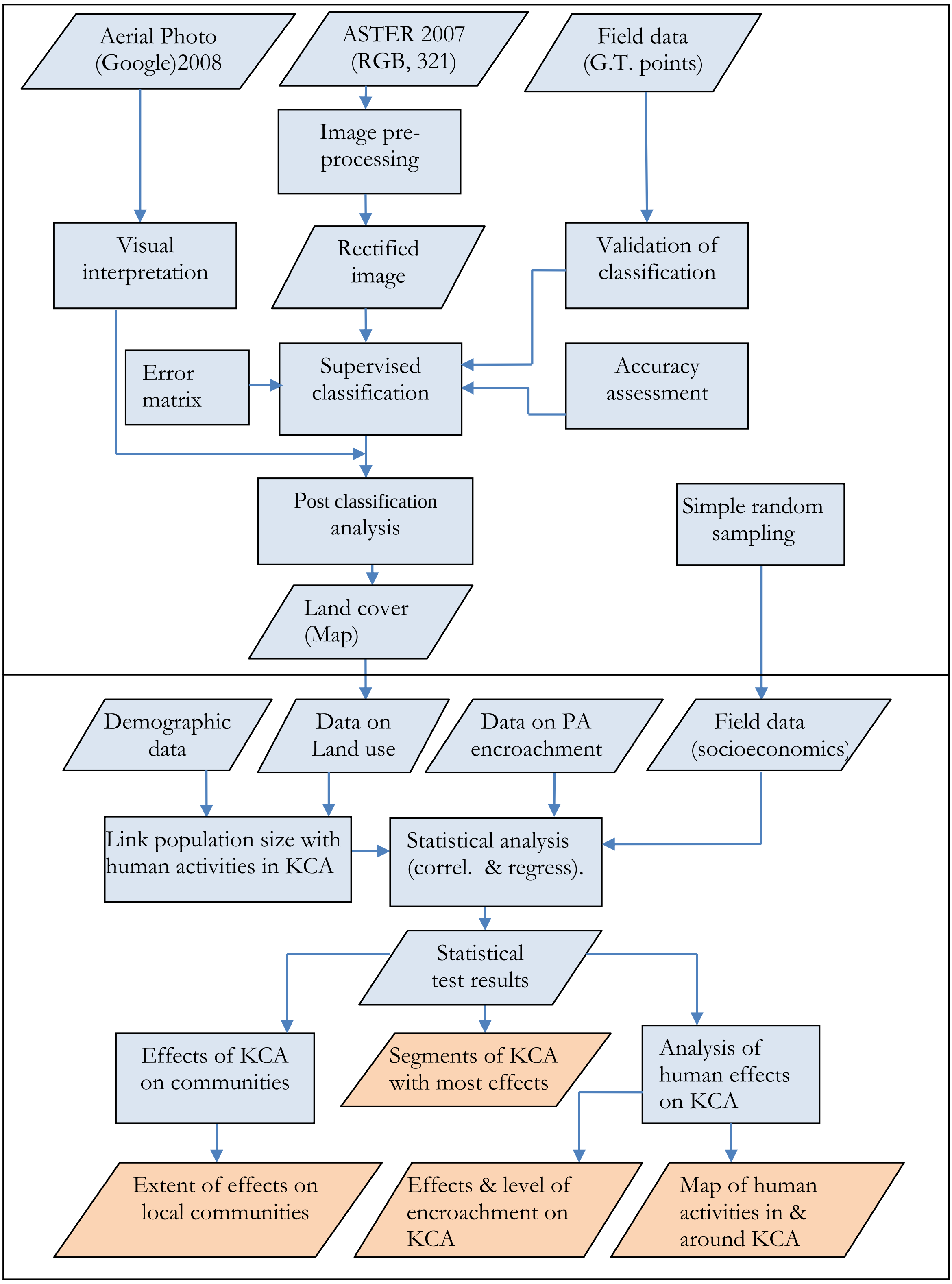

Figure 3.4: Flowchart of research methods.

3.4. Satellite image importation and pre-processing

Pre-processing is an essential activity in analysis of remote sensing imagery. This is in order to address sensor and platform distortions that may be present in the image (Lillesand & Kiefer, 2004). These are done to ensure that information obtained from remote sensing imagery represents reality as exists on the ground. Multi-spectral satellite imagery, ASTER RGB bands 123 acquired on September 24 2007 covering KCA, was obtained for this research. The image was purposely used to map and analyze changes in land cover that have occurred in the study area. The ASTER image was first converted from Hierarchical Data Format (.hdf) to Tagged Image File Format (TIFF) so as to be able to work with it in GIS software. Importation of the image was performed using ERDAS 9.2 software (Import and Export options) and then converted to Imagine format (IMG). It was then imported and geo-referenced into the same coordinate system. To geo-reference an image is to define its existence in physical space. That is to establish its location in terms of map projections or coordinate system (Franklin *et al.,* 2003).

3.4.1. Geometric correction

Remotely sensed imagery usually contains geometric distortions and so they cannot be used directly with base map products (Lillesand & Kiefer, 2004). Road and river maps are used as a reference map to register them to real world coordinates. The image was geometrically corrected to the local spatial reference system, Transverse Mercator projection in Leigon datum (See appendix A.2 for image projection system).

3.4.2. Radiometric correction

Radiometric correction is a process to remove undesired influence of system noise and atmospheric interference on image brightness value (Lillesand & Kiefer, 2004). Undesired influences have additive effects on remote sensing imagery in the form of variation in scene illumination and viewing geometry, often resulting in higher digital number (DN) values, and reducing the contrast (Mas *et al.,* 2004). Haze reduction for instance, is done by subtracting the DN value that is considered as the haze value, which can be seen from the lowest value in the histogram. Also the presence of thick cloud cover is a frequent challenge in the tropical world (Mas *et al.,* 2004). As a result of this challenge it was pretty difficult to acquire latest cloud-free imagery covering the study area for this research. Clouds and their cast shadow covered portions of the multi-spectral ASTER 2007 imagery used in the study. The portions covered by clouds were clipped off and so the land cover on those areas could not be analyzed.

3.5. Field work

Field work was carried out in the study area from September 25 to October 30 of 2010. Activities involved in field work were questionnaire surveys in 40 sample communities, collection of ground truth data for classification of ASTER imagery and analysis, determining illegal human activities along transects in KCA and GPS location of study communities. Other activities included collection of data on poachers' arrest in KCA, poaching trails and poachers' camps, data on elephant crop raiding in fringing farms and demographic data of communities. The procedure used in data collection for this research was simple random sampling.

3.5.1. Simple random sampling

The study took place in KCA and 5km belt of its bordering landscape. The landscape was divided into 10 rectangular sampling plots of 5km X 5km, based on geographic coordinates in the area. This was in order to ensure equal representation for the different communities in the sampling scheme. The scheme was particularly to take care of minority groups as well as people of varied ethnic and cultural background in the area. This scheme was also used in collecting ground truth points. A list of all communities within each of the 5km X 5km plots was generated and 4 randomly selected from each plot. This generated a sample size of 40 communities from which respondents were further sampled for questionnaire surveys.

3.5.2. Questionnaire surveys

Semi-structured questionnaires were designed and field surveys conducted in the 40 sampled communities. In all 120 respondents (3 from each of the 40 communities) were interviewed, comprising of 109 males and 11 females. The interviews were conducted in the local dialect of respondents (Twi). Focused group discussions and key informant interviews were as well held in some communities to clarify specific responses. Respondents were identified through simple random sampling procedure by means of a ballot. Residents in each of the sampled communities were called to a gathering by opinion leaders of the community and asked to pick a folded piece of paper each. The 3 people who randomly picked pieces of paper that bore the numbers 1, 2 and 3 eventually became respondents for each community and were therefore slated for an interview upon which date and time were scheduled. The procedure was the same in selecting all 120 respondents throughout the 40 sample communities. West & Brockington (2006) used a similar sampling scheme in assessing stakeholders' perception on forest conservation in Thailand. It must however be acknowledged that attendance at some of the gatherings was rather poor and females in particular woefully failed to attend and that explains the low number of female respondents. Also in some communities respondents selected could not be found on the interview day, and in such situations substitutes were used, and in other cases interviews had to be rescheduled.

3.5.3. Illegal activities encountered along transects in KCA

Signs of illegal activities found along 1km transect into the PA were recorded to determine the relationship between communities (in terms of mean distance from KCA) and number of illegal activities encountered within KCA. Geographic locations of settlements were determined with a GPS device and their mean distances in kilometres from the borders of KCA calculated. A one kilometre transect was laid in the PA perpendicular to the location of each sample community, and all signs of illegal activities encountered along transects recorded with the help of a GPS device. The procedure was the same for all the 40 transects along the 40 sample communities. Because of the relatively large area to be covered and time constraints, it was decided not to cut straight-line transects through the PA. Instead straight transects of least resistance were employed (Sam, 1996; Jackmann, 2008). Rangers and patrol staff of KCA assisted in the collection of these data, mostly because of their technical knowledge in identifying and distinguishing between types of illegal activity encountered, as well as serving as field guards during the forest hike. In all 233 different signs of illegal activities were encountered, ranging from hunters' trails, cartridge shells to cutting of raphia palms (*Raphia farinifera*) (See appendix A.6). Mean distances of communities from the PA and number of illegal activities encountered along each corresponding transects were analyzed statistically in order to determine their correlation.

3.5.4. Data on poachers arrest in KCA

KCA is managed with legal enforcement and as such rangers and patrol staff undertake day and night patrols, as well as long and emergency patrols in order to apprehend and also ward off encroachers. Records on the number of poachers arrested between 1992 and 2009, type of offence committed and the community where the offenders reside was obtained from park authorities for analysis. Various offences ranging from possession of bushmeat, illegal entry, cutting of cane and illegal cultivation in the PA and many more offences were recorded during the period. Invariably offences recorded were not different from illegal activities encountered on transects in the KCA.

3.5.5. Demographic data on communities

Population data for 1970, 1984 and 2000 covering sample communities and other rural areas not close to a PA were collected from the offices of the Ghana Statistical Services (GSS). The purpose was to analyze and compare population growth trends in communities around KCA and other areas in the country.

3.5.6. Ground truth data

Ground truth data were collected with a GPS device (Garmin 60cx) from each of the sampling plots. Since ASTER imagery of the study area was categorized into 5 main land-use/cover classes: forest, mixed crops, oil palm plantation, cocoa farm and built-up area, 25 ground truth points were collected from each sampling plot (thus 5 points from each land cover class within a plot). This generated a total of 250 points, and 5 additional points collected from interior of the PA to add up to 255 points all together. This was to ensure a high accuracy after classification of the ASTER imagery (Congalton, 2001). 150 of the field points were used for training samples to perform supervised classification of the satellite image and then all the 255 points again used for validation and accuracy assessment.

3.6. Image classification

Land cover classes are often derived from satellite imagery by utilizing computer-assisted image classification algorithms (Jensen *et al.,* 2008). Within the scope of this study, image classification is defined as the extraction of distinct classes or themes, land-use/cover categories, from ASTER 2007 imagery based on image pixels. There are two primary methods of remote sensing image classification: unsupervised and supervised classification (Lillesand & Kiefer, 2004). A requirement of supervised classification techniques is that the analyst defines the spectral characteristics of the classes by identifying sample areas (training samples). The training samples are pixels that represent known locations of the area being classified and are used to classify the remainder of the image. Supervised classification method with Maximum Likelihood classifier algorithm was used in this research because of the researcher's familiarity with the study area. Maximum Likelihood classifier is a parametric method in remote sensing image classification that is commonly used because it offers high classification accuracy (Hubert-Moy *et al.,* 2001). In satellite image classifications, single supervised or unsupervised classification technique alone is often not enough (Franklin *et al.,* 2003). Modifications of image classification techniques are most often required in order to assess for classification accuracy. Accuracy assessment is often carried out by comparing sample pixels from the classification results to ground truth data collected during field visits. Consequently 255 points collected from the field of study were used for this purpose. Classification error matrix showing overall accuracy, producer's accuracy and user's accuracy were computed to evaluate results of the classification. Another parameter that was used in this research is kappa (k^) statistics, which determines the extent to which classification results surpass random assignment of pixels (Lillesand & Kiefer, 2004).

3.7. Statistical analyses

Correlation and regression were the main statistical analyses in this research. Correlation expresses relationship between two or more variables to see how closely they are associated. In this research illegal activities and mean distance of communities as well as human populations were correlated. Linear regression was employed to model the relationship between the number of illegal activities encountered and mean distance of settlements from KCA, and population size in each community. The quantitative relationship is expressed by an equation and its graphic representation (Husch *et al.*, 2003). The square value of the correlation coefficient is referred to as coefficient of determination and denoted by (R^2). It can be interpreted as indicating the percentage of variation in one variable that is associated with other variable (Husch *et al.*, 2003). Following from the methods described by Boyce and McDonald (1999) a Generalized Linear Model (GLM) was used for statistical modelling of the occurrences of illegal activities along each transect, (that is to predict responses for the dependent variable). The GLM has been effective in statistical modelling with any form of data; abnormal distributed data, continuous and/or categorical independents (Pampel, 2000). A binomial distribution was as well used with the logit link function. In the logit model, the sign of the coefficients is interpreted the same way as in a standard regression: a positive coefficient increases and a negative coefficient decreases the probability of occurrence of illegal resource extraction. Similarly, the exponential values of the coefficients exp (β_0) explains the change in the odds of the dependent variable for a unit change in the value of the respective independent variable, all other things being equal (Field, 2005). The general structure of the model was:

$$E(p_i) = \frac{\exp[\beta_0 + \sum_i f_i(z_{ij})]}{1+\exp[\beta_{0+} \sum_i f_i(z_{ij})]} \text{..............................equation (1)}$$

where: p_i is the total number of illegal activities encountered along each transect, β_0 is a parameter to be estimated and z_{ij} is the value of the *j*th explanatory variable in the *i*th transect fitted as some unknown function, f_i to be estimated.

In order to model the various types of illegal human activities within 1km of the PA, the number of each type of activity encountered along a transect was log-transformed, to obtain a normal distribution of the data that allowed the use of a linear model. The general structure of the model was:

$$In(n_i) = \beta_o + \sum_i f_i\ (z_{ij}) \text{................................equation (2)}$$

where: n_i is the number of individual illegal human activities in the *i*th of various types fitted as some unknown function f_i to be estimated.

4. RESULTS

4.1. The existing land-use/cover types around KCA

Supervised classification of multi-spectral ASTER 2007 imagery categorized the study area into 5 major land-use/cover types, namely: forest, oil palm plantation, mixed crops, cocoa farms and built-up/bare. Forest refers to the area within the PA and small patches of fallow lands around. The 4 remaining classes are the dominant land-use and cover types around the fringes of KCA. However portions within KCA after classification showed the other 4 cover types, other than forest. Based on expert knowledge these non-forested land-uses inside the PA were grouped and labelled disturbed forest (Figure 4.1).

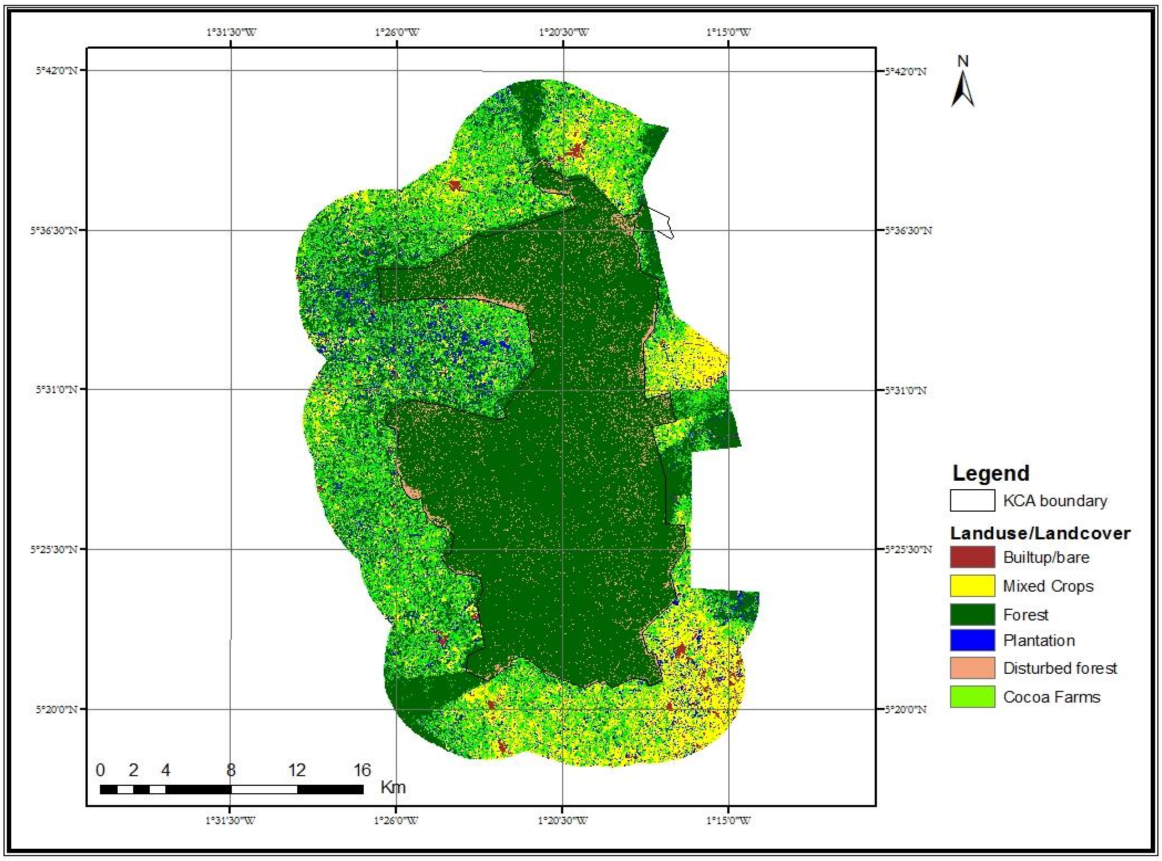

Figure 4.1: Supervised classification of ASTER 2007 image of study area.

The categories are elaborated in Table 4.2. The resulting land cover map specified dominant use of the landscape and a basis for analyzing effects of human activities on biodiversity in and around KCA. The map shows the extent to which habitats on the neighbouring landscapes have been converted from forested ecosystems into varied land-use/cover types. This demonstrates the effects that human activities have had on biodiversity of the study area.

Table 4.1: Description of land-use/cover types in the study area.

Land cover type(Class name)	Descriptions
Forest	Forested areas predominantly covered by trees with or without close canopy. It includes KCA and fallow lands in the surrounding landscape.
Oil palm plantation	Areas predominantly covered with oil palm plantations *(Elaeis guineensis)* on the fringes of KCA
Mixed crop	Areas covered with a mixture of crops that include maize, plantain, cocoyam and cassava on a single plot of land on the fringes of KCA.
Cocoa farm	Areas predominantly covered with matured cocoa (*Theobroma cacao*) trees along the fringes of KCA
Built-up/bare	Areas dominated with buildings, roads and other human infrastructure, as well as exposed soils resulting from human activity or natural cause.
Disturbed forest	Areas of forest inside KCA that classified other than forest and are likely results of disturbances by humans, including tree removal, clearing, fire or cocoa farms.

Table 4.2: Land-use/ cover types and size covered in the study area (ha).

Land cover type (Class name)	Land use	Descriptions	
		Area covered (ha)	Percentage (%)
Forest	Conservation Area/fallow patches	43,764.8	49.5%
Cocoa farms	Farm land	19,570.43	22.1%
Mixed crops	Farm land	14,686.18	16.7%
Oil palm plantations	Farm land	4,505.06	5.2%
Built-up/bare	Settlement/bare areas	1,440.88	1.6%
Disturbed forest	Farms and other illegal activities as well as natural impacts (eg. Fire, wind storm etc.)	4,263.72	4.9%
Total Area	-------------	88,231.69	100.0%

From table 4.2 Forest constitutes the major land-use/cover type covering 49.5% of the study area followed by cocoa which covered 22.1%, mixed crops 16.7%, plantations 5.2% and 1.6% for built-up. Then portions within the forest class that classified differently and was grouped as disturbed forest constituted 4.9%. Clearly the intention of every farmer on the fringes of KCA is to grow cocoa. Partly because of government interventions that have acted to boost the production of cocoa in the country, and also because cocoa is widely considered among cocoa farmers as an important security against old age in Ghana. As observed from the land cover map cocoa occupies the greatest portion of the landscape that fringes KCA. The average size of a cocoa farm ranges between 7 and 8 ha. Cocoa farms generally are difficult to distinguish and classify accurately when located within a forest because of similarity in their spectral reflectance with pristine forest. This has been attested to by most researchers over the years. However, in the case of this research cocoa farms had relatively high classification accuracy (Table 4.3) as a result of the fact that they are located outside of the PA, invariably with no forest tress found in them. Again the high accuracy could be attributed to the large number of ground control points collected and used in validation. As a result while outside of the PA most of the impacted forest is indeed covered by cocoa, this is not the case inside KCA. Therefore it could not be assumed that other areas inside KCA that appeared disturbed are cocoa farms, hence described as "disturbed forest".

The cultivation of mixed crops mainly maize, cassava, plantain, cocoyam, vegetables usually planted together on a single piece of plot is common among farmers, meant for subsistence and occasionally for commercial purposes. Mixed crop fields are usually small in sizes in comparison to cocoa, ranging between 0.2—3.0ha on average and located in between cocoa farms and palm plantations. This situation was a major challenge in classifying the cover types distinctly. Cultivation of oil palm plantation has recently gained popularity in the area as a commercial crop mainly for palm oil extraction even though not much of the landscape is committed to it as to the cultivation of cocoa. Settlements or built-up in the area constitute various types ranging from hamlets, cottage, small towns to sizeable communities mostly built with local materials. The landscape was also covered with very small fallow lands and patches of uncultivated lands. Some of these landscapes were left uncultivated because according to respondents elephants within KCA habitually raided crops that were previously grown on those lands and so the owners abandoned them for lands that were perceived to be less prone to elephant raids in the area. Other fallow lands in the area were said to be uncultivated because of land use conflicts among some farmers. These small patches of fallow landscapes were classified as forest for the purpose of this research.

4.1.1. Accuracy Assessment

Tables 4.3 present result of accuracy assessment for the supervised classification of ASTER 2007 imagery of the study area.

Table 4.3: Accuracy assessment report.

Class name	Reference totals	Classified totals	Number correct	Producer's accuracy(%)	User's accuracy(%)	Kappa
Forest	89	89	79	88.76	88.76	0.82
Plantations	21	22	16	76.19	72.73	0.70
Cocoa farms	70	72	60	85.71	83.33	0.77
Mixed crops	57	55	45	78.95	81.82	0.76
Built-up/bare	18	17	13	72.22	76.47	0.74
Totals	255	255	213			
Overall accuracy = 83.53%						
Overall Kappa statistic = 0.77						

Classification accuracy was assessed based on producer's accuracy, user's accuracy and overall accuracy. "Forest" has the highest producer's accuracy of 88.76%, followed by "cocoa farms" 85.71%, "mixed crops," "plantations" and "built-up". This implies that forest has the highest probability of a reference site being correctly classified. It is calculated by dividing the number of correct pixels for a class by the actual number of ground truth pixels for that class (Lillesand & Kiefer, 2004). Similarly for user's accuracy "forest," "cocoa farms" and "mixed crops" were again the most accurately classified with user's accuracies of 88.76%, 83.33% and 81.82% respectively. User's accuracy is calculated by dividing the number of correct classifications by the total number of classifications in the category. The implication therefore is that "forest," "cocoa farms" and "mixed crops" have the highest probability that a pixel on the map actually represents the category on the ground. "Built-up" and "plantation" in comparison were less accurate with user's accuracy of 76.47% and 72.73% respectively. Since "disturbed forest" is part of the forest within KCA it shares in the same classification accuracy as the forest. The overall accuracy of classification results was 83.53% and the kappa coefficient is 0.77. The Kappa coefficient implies 77% of the classification agrees with the reference data. See appendix A.3 for confusion matrix of errors & kappa).

4.2. Demographic characteristics of the study area

Demographic data for the study communities for 1970, 1984 and 2000, were obtained from the Ghana Statistical Services (GSS) and growth rates calculated in order to analyse population growth trends. Data was not available for the 1990s around the period when KCA was established as there was no population census in the country that year. However, comparison of population growth trends between 1984 and 2000 showed that the environs of KCA experienced more people during the period after its establishment. The total population of sampled communities in 1984 was 10,527 and this doubled to 21,749, in 2000. Since natural growth might have played a role in these trends average growth rates were determined (See appendix A.4 for population summaries). The periods between 1970 and 1984 registered a growth rate of 3.3%, and between 1984 and 2000 had a growth rate of 4.1%. This implies population growth rates were higher by 0.8% after the creation of KCA. Again the growth rates between 1984 and 2000 was compared with rural growth rates, growth rates for Central Region where KCA is situated in Ghana, as well as growth rates for the country as a whole (Figure 4.2).

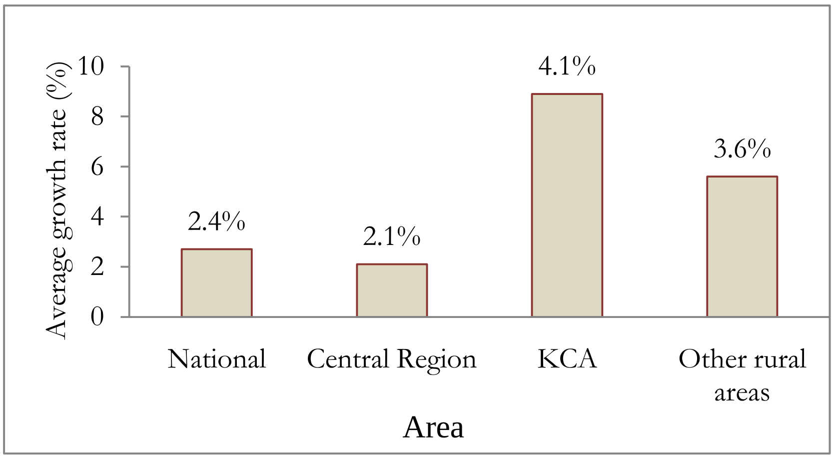

Figure 4.2: Comparison of population growth rates (1984-2000).

From figure 4.2 growth rates for KCA were again higher than 2.4% for the nation, 2.1% for the Central Region and 3.6% for rural areas during the period. The results point to the fact that the study area indeed experienced increase in human population after its establishment partly attributed to migration of people in to the area. Therefore land conversions and varied land-use/cover types observed from the land-cover map of the study area is a result of increased human populations (See appendix A.4 for population figures). Tables 4.4 and 4.5 respectively, show population growth trends in Ghana and in the study area. Population growth rates were derived using the population growth rate formula, r = $(P^1 - P^0)/P^0 * 100/t$ where, r = average annual rate of growth, P^1=current population totals, P^0=previous population totals, t= the number of years between censuses (Witmeyer *et al.,* 2008).

Table 4.4: Population growth trends in Ghana (1970 - 2000).

Year	Population (million)	Average growth rate (%)
1970	8,559	2.2
1984	10,736	2.5
2000	18,412	2.3

Table 4.5**: Population growth trends in study communities (1970-2000).**

Year	Population (thousands)	Average growth rate (%)
1970	5,461	3.2
1984	10,524	3.4
2000	21,749	4.8

Source: Population and Housing Census of Ghana (1970, 1984 & 2000) (GSS).

4.3. Effects of land-use types on the ecological functions and biodiversity conservation in KCA

Accelerated growth in human populations around KCA has been identified as a major threat to the PA (IUCN/PACO, 2010). As observed from the land cover map increased human population on the fringes of KCA resulted in habitat conversion of the bordering landscape as well as human disturbances within KCA. Whenever the use of a resource violates laid down regulations it becomes illegal resource use or an illegal activity (Holmern *et al.,* 2007). Apart from disturbed spots within the borders of the PA, a number of other illegal activities were encountered along transects into the PA. Illegal activities are a major concern in biodiversity conservation because their biological impacts range from declines in genetic diversity and species richness to changes in community composition and ecosystem services (Okello *et al.,* 2008). Illegal activities such as bushmeat hunting and land clearing in particular impact rainforest by wiping-out large mammals and birds that are important for dispersing tree species. The situation changes the structure of forest species by favouring small-seeded trees over large-seeded, leading to lower tree diversity and hence degradation of forest landscapes (Holmerm *et al.,* 2007). A total of 233 signs of illegal activity were found along 40 (1km length) transects in KCA (See appendix A.6). The activities are made up 13 different types (Figure 4.3). Of the activities, harvesting of raphia palm (*Raphia farinifera*) was the highest with 20.1%. This might probably be because raphia palm is used extensively by the locals as building materials for their mud houses. Land clearing for agriculture coupled with competition for the harvest of raphia on the fringing landscape is reported to have completely wiped-out the resource outside of the PA. Therefore illegal harvest of raphia and other building materials from the PA is a common practice among locals in the study area.

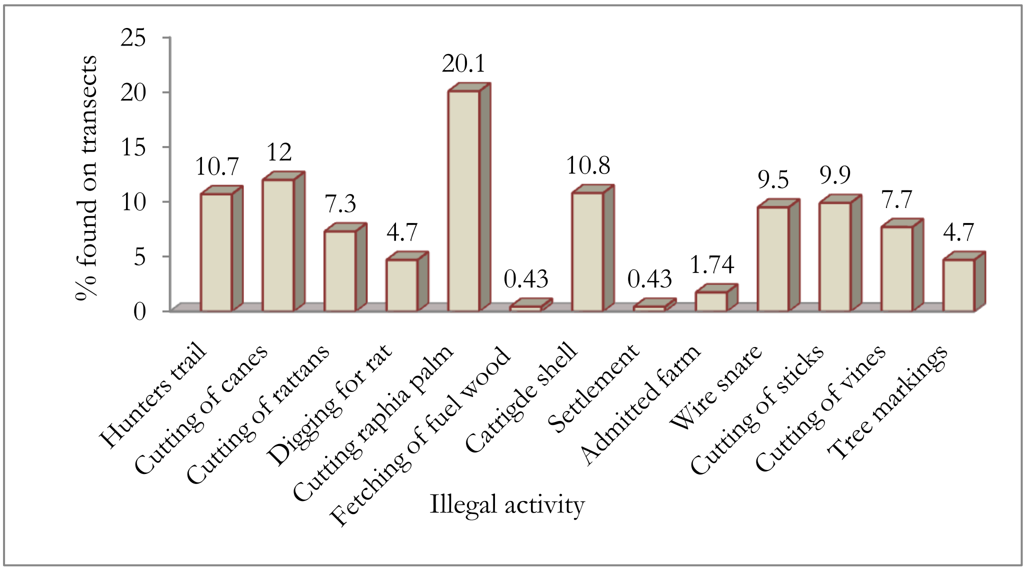

Figure 4.3: Percentage of illegal activities along transects in KCA.

Cartridge shell constitutes the next highest activity with 10.8%, followed by hunters' trails with 10.7 %. These two activities, together with rat hunting and wire snares, also appeared to be high in KCA probably because bushmeat is a primary source of dietary protein and livelihood for rural communities in many parts of Africa (Bakarr *et al.,* 2001; Fa & Meeuwig 2002). To these end communities around PAs often take advantage to engage in bushmeat hunting for both commercial and subsistence purposes. Other illegal activities encountered include cutting of canes and rattan *(Berchimia scandens)* and they constitute 12% and 7.3% respectively. Canes and rattans are harvested and used in weaving baskets for carrying cocoa pods and other foodstuffs on farms. Figure 4.4, 4.5, 4.6 and 4.7 illustrate number of illegal activities encountered along each of the 40 transects.

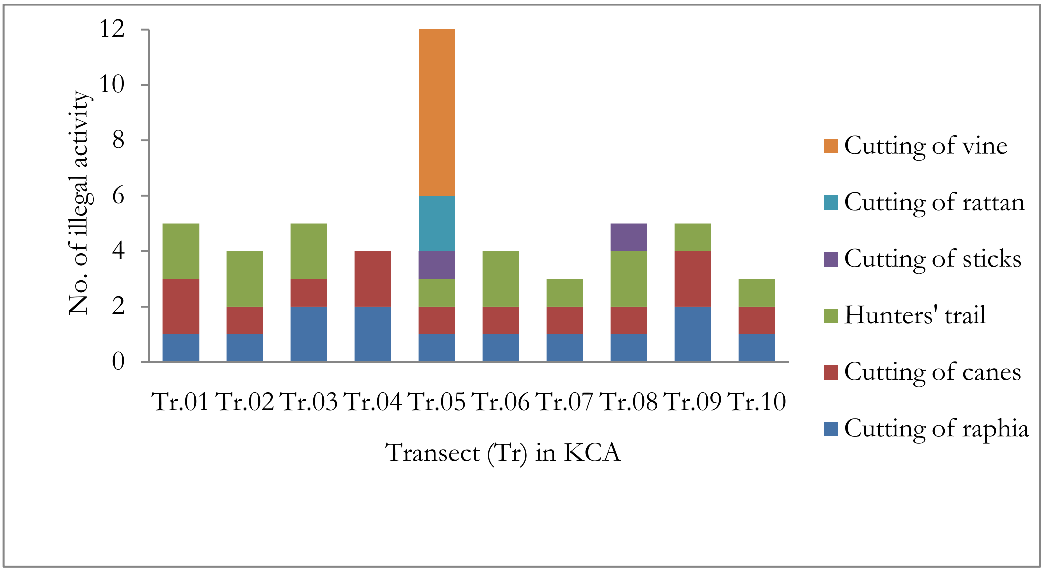

Figure 4.4: Number of illegal activities along transects 01-10

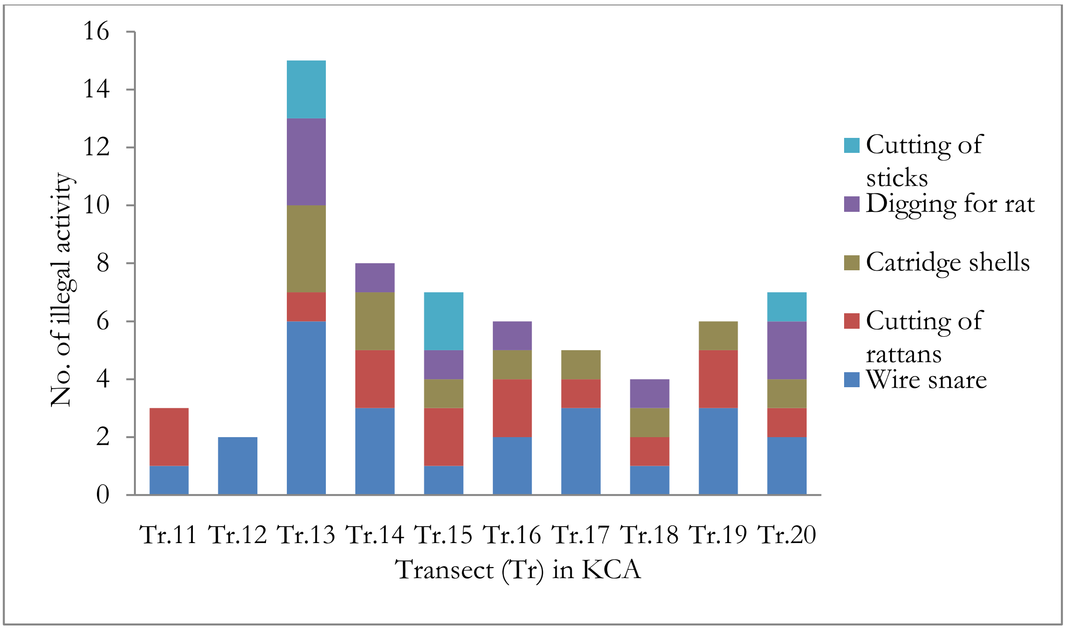

Figure 4.5: Number of illegal activities along transects 11-20.

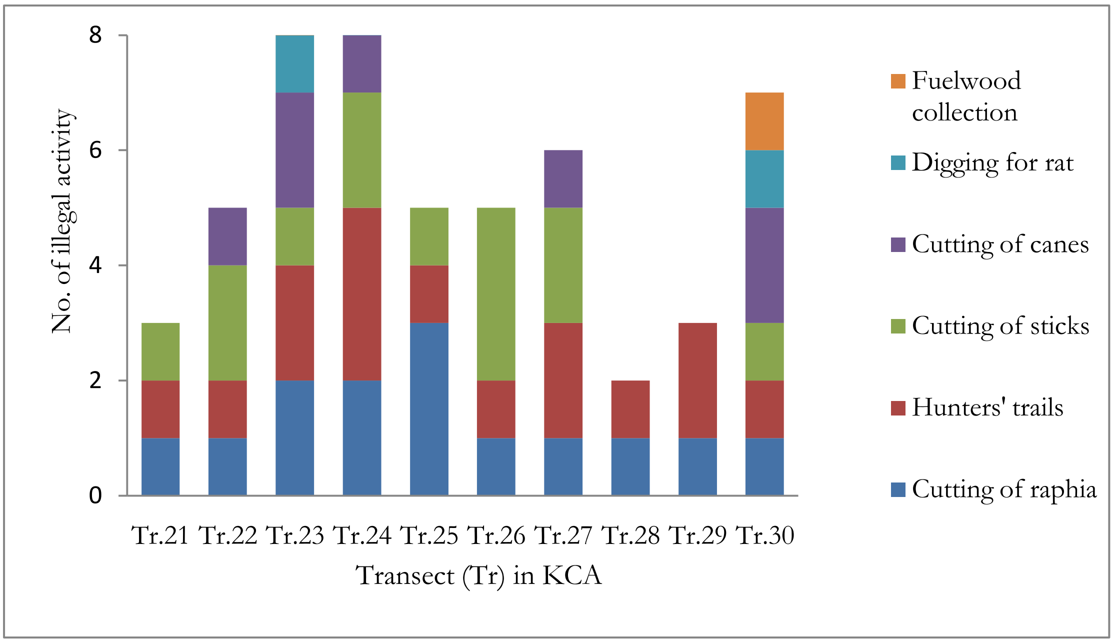

Figure 4.6: Number of illegal activities along transects 21-30.

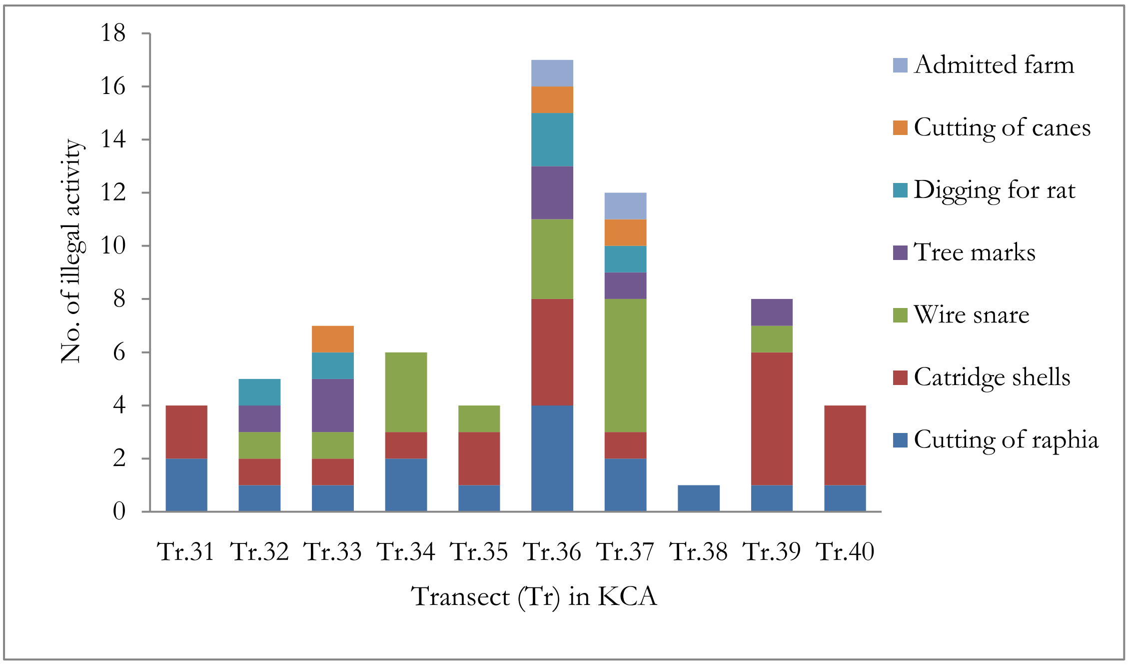

Figure 4.7: Number of illegal activities along transects 31-40.

Figure 4.8 shows the spatial location of illegal activities in KCA.

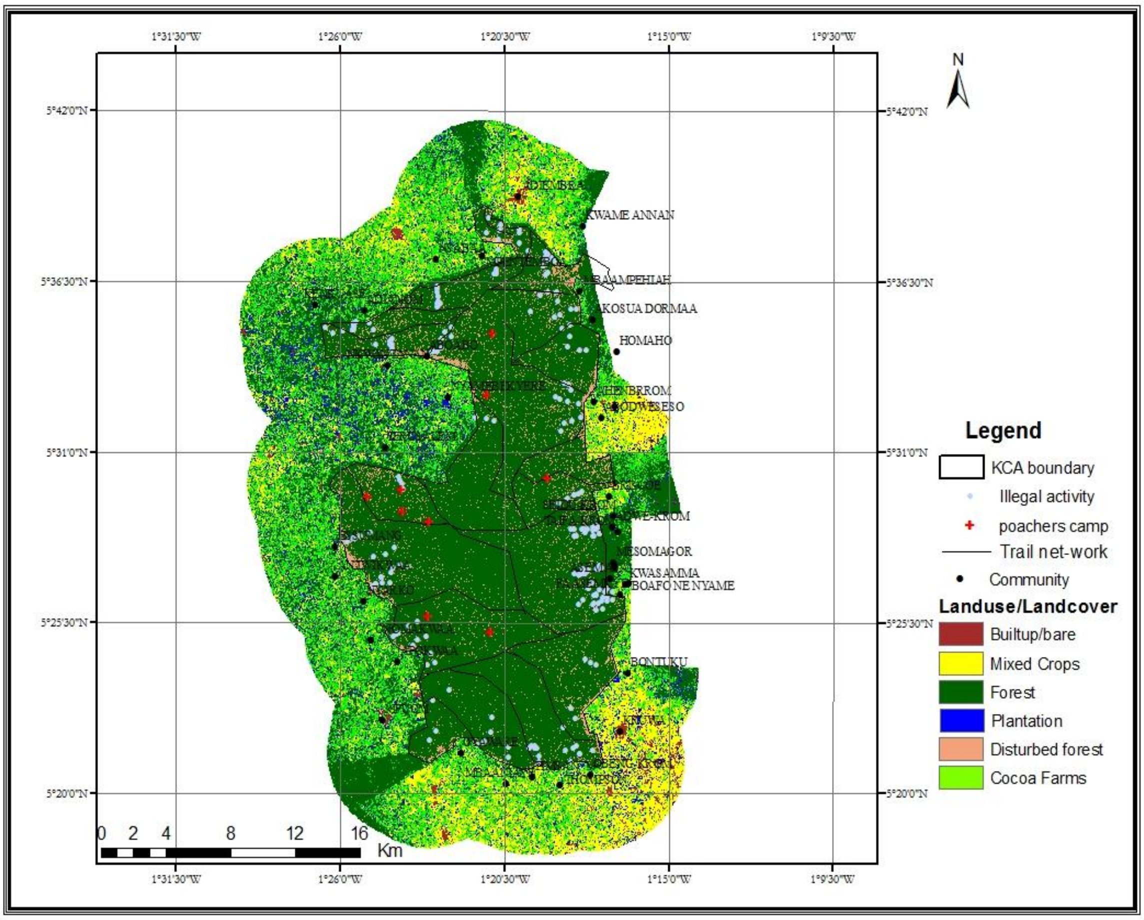

Figure 4.8: Classified ASTER image showing spatial distribution of illegal activities in KCA.

4.4. Results from statistical analyses

Statistical analyse were conducted to explore how illegal activities in KCA are influenced by the mean distances of communities from the PA on one hand, and their population sizes on the other.

4.4.1. Mean distances of communities from KCA and illegal activities

Mean distances of communities from KCA and number of illegal activities encountered along transects were correlated. The correlation yielded R= -0.446, p< 0.004 implying a negative correlation between the two variables. A regression statistics (ANOVA, Single Factor) of R^2= 0.20 at $p < 0.05$, implied 20% of the total variance in dependent variables, (illegal activities) could be explained by the independent variables (mean distances), (See appendix A.5 for statistical results).

The regression equation is:

$$Y = \beta_0 + \beta_1 x$$

$$Y = 1.23 - 0.07x$$

where; Y = dependent variable (illegal activities)

β_0 = intercept (constant)

β_1 = number of illegal activities

x = independent variable (mean distance)

From analyses communities located relatively close to KCA (between mean distances of 0.10 and 0.90 km) recorded high numbers of illegal activities in KCA as a result of the 20% variance in illegal activities that is explained through distance of communities from the PA. Transect that recorded the highest number of illegal activities was the one along Aboabo. It has a mean distance of 0.20km from KCA and recorded 17 illegal activities, or 7.2%. Transects along Adianum encountered 15 illegal activities or 6.4% with mean distance of 0.80km from the PA. Other transects with similar characteristics were those found along Antwikwaa, Nkwantanaan, Gyahadzi, Apokwaa, Briscoe I, Mpentemboa, Nsabaa, Obengkrom, Adwe-krom, Essuman, Fa Asemkye and Mesomagor (See appendix A.6 for population summaries).

4.4.2. Population size as a basis for determining level of encroachment in KCA

Illegal activities were also correlated with size of human population in each community. The last Population and Housing Census in Ghana were in October of 2010 and as at the time of this research the census report was not yet compiled. And so population data for the 2000 Population and Housing Census were used for this analysis. Projection ratios for the 2000 population could have been used to represent population figures in 2010 for these analyses. However demographers often criticize projection ratios since they often cast doubts on their validity and therefore cannot be tied to meaningful alternative demographic scenarios (Smith & Sincich 1990; Voss & Balkrishna 1992). Population sizes of communities and number of illegal activities encountered within their vicinity were correlated, yielding a positive but very insignificant correlation index $R = 0.068$, $p > 0.698$. A regression statistics of $R^2 = 0.04$, at $p < 0.05$. (ANOVA, Single Factor), (See appendix A.5 for statistical results).
The regression model is:
Y = a + bx
Y = 5.924944404 + 0.000992907X
where, Y = independent variable (illegal activities)
    a= intercept (constant)
    b= number of illegal activities
    x = independent variable (population)
Hence, Y = 5.924944404 + 0.000992907X indicates a positive but insignificant, relationship between population size and illegal activities in KCA.

From table 4.6 transects along communities situated between mean distances of 0.10 and 0.90 km from the borders of KCA recorded relatively high number of illegal activities. These communities however had relatively low population figures.

Table 4.6: Comparison of mean distance and illegal activities in KCA.

Community	Population in 2000	No. of illegal activities along transects	%	Mean distance from KCA (km)
Aboabo	532	17	7.2%	0.20
Adianum	299	15	6.4%	0.80
Antwikwaa	479	5	5.1%	0.50
Nkwantanaan	398	12	5.1%	0.80
Gyahadzi	76	7	3.0%	0.30
Apokwaa	184	8	3.4%	0.80
Briscoe I	389	6	2.6%	0.10
Mpentemboa	56	5	2.1%	0.10
Nsabaa	108	10	4.3%	0.90
Obengkrom	156	8	3.4%	0.70
Adwe krom	543	7	3.0%	0.40
Essuman	243	7	3.0%	0.20
Fa Asem Kye	421	9	3.8%	0.30
Mesomagor	395	7	3.0%	0.70
Adwe-krom	543	7	3.0%	0.40
Akosua Doma	432	5	2.1%	0.50
Asem Asa	593	5	2.1%	0.50
Boafo Yena	718	6	2.6%	0.20
Nyarko	203	6	2.6%	0.20

From table 4.7 transect along communities with relatively high population figures recorded low numbers of illegal activities. However these communities are all located between mean distances of 1.0—2.0km from the borders of KCA.

Table 4.7: Comparison of population and illegal activities in KCA.

Community	Population in 2000 (000)	No. of illegal activities along transects	%	Mean distance from KCA (km)
Adiembra	1,987	3	1.3%	1.5
Ahenbrom	1,988	4	1.7%	1.0
Abodweseso	976	2	0.9%	1.3
Nyamebekyere	945	1	0.4%	2.0
Homaho	1,182	3	1.3%	1.0
Mfoum	2,910	5	2.1%	1.8
Kruwa	1,972	3	1.3%	1.9

Apparently the following inferences could be drawn concerning local communities and encroachments within KCA by comparing tables 4.6 & 4.7: (1) communities that are located closer than 1km to the borders of KCA tend to encroach more in the PA although distance was found to be only 20% accountable for the variance in illegal activities; (2) communities with relatively high human populations also encroach more in the PA but at a very low rate because population size was found to be only 4% responsible for the variance in illegal activities (See appendix A.5 for statistical results); (3) communities located farther than 1km from KCA encroach less on the PA because of their mean distances from the PA. Therefore distance at which a community is located from KCA was found to be more accountable in explaining levels of human encroachment in KCA than size of population. Although apart from distance other variables could be accountable as well. Figure 4.9 illustrates location of illegal activities and sizes of sample communities in a population density map of the study area.

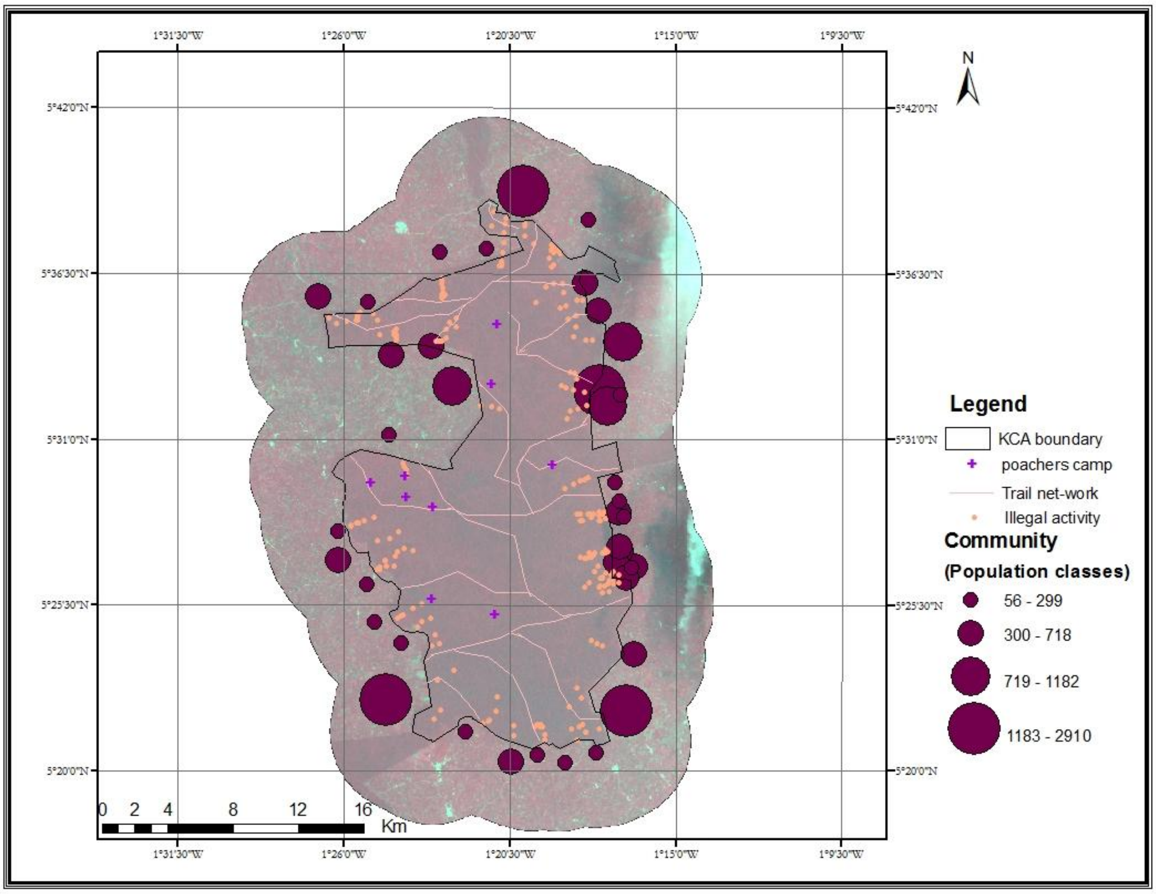

Figure 4.9: Population density map of sample communities (unclassified ASTER image).

4.5. Analysis of encroachers arrest in KCA

KCA employs conventional law enforcement in the form of foot patrols within the PA (Jachmann, 2008). These patrols are undertaken by park rangers and field staffs with the main objective to arrest and deter encroachers found within the PA. There are day and overnight patrols, embarked upon during the day and night respectively, short and long distance patrols, as well as emergency patrols. In order to compare encounter rates of illegal activities and large mammals with different conditions in PAs a standardized measure of patrol effort is used (Hood & Parker, 2001).

A measure of efforts for comparing areas with each other as applied in the case of KCA is effective patrol man—days per unit time (Jachmann, 2008). During patrols the staff record GPS location and name of the area patrolled, GPS locations of major hunters' trails, number of encroachers intercepted and type of weapons in possession, type and number of illegal activities encountered, animal sightings and other events of interest (Jackmann, 2008). Figure 4.10 shows number and percentage of arrests made by field staff in KCA between 2002 and 2009. Offences for which the arrests were made are not different from the illegal activities encountered along transects. They range from possession of bushmeat, arms and ammunitions, illegal cultivation, to cutting of canes and raphia (*Raphia farinifera*) in the PA. These arrests further validate occurrence of illegal activities in KCA. It should however be noted that the arrest may represent a tip of the iceberg since many encroachers are able to escape arrest in forest PAs because of the difficulty in detecting from afar within a forest.

Figure 4.10: Percentage of poachers arrested in KCA (2002 to 2009).

Source: Poachers arrest record in KCA, 2010.

2004 recorded the highest numbers of arrests encounter with 26.8%. This was reportedly because of introduction of a new measure of patrol efforts at the start of 2004 known as the effective patrol man—days per unit time (Jackmann, 2008). The new system seems to have improved upon patrol staff performance and so increased the encounter rate of encroachers in the PA. Arrests declined sharply to 4.8% the following year probably because the locals may have gotten wind of the new system and arrests made the previous year, and so decided to temporary withdraw. Otherwise new tactics might have been devised by poachers through which they could outwit patrol staff. Percentage of poachers arrest rose again to 14.3% in 2006, 19.0% in 2007 and fell again by 2% in 2008 to 17.9%. It must be pointed out that arrest record for 2009 covered only January and February. There was no data on arrest for the rest of the ten months, probably percentage of arrest could have been higher than the 3% recorded for the year. Wildlife poaching in particular has been identified as a persistent illegal activity in forest reserves (Blom *et al.,* 2004; Jackmann, 2008). In particular commercial poachers are noted of making use of a net-work of trails they create, often walking long distances into the PA. Others are described as "hit and run" poachers who hunt in the PA without necessarily using trails. The second groups of poachers' are those who hunt purposely for subsistence. They usually sneak in to the PA and once inside begin to mark trees and saplings as signs to enable them determine their way out, and on killing an animal quickly move out without staying long in the PA.

4.6. Effects of topography on illegal activities in KCA

Topography within the borders of KCA is generally varied with undulating terrain that ranges on average between 150—350m above sea level (Jackmann, 2008; Barnes *et al.,* 2003).

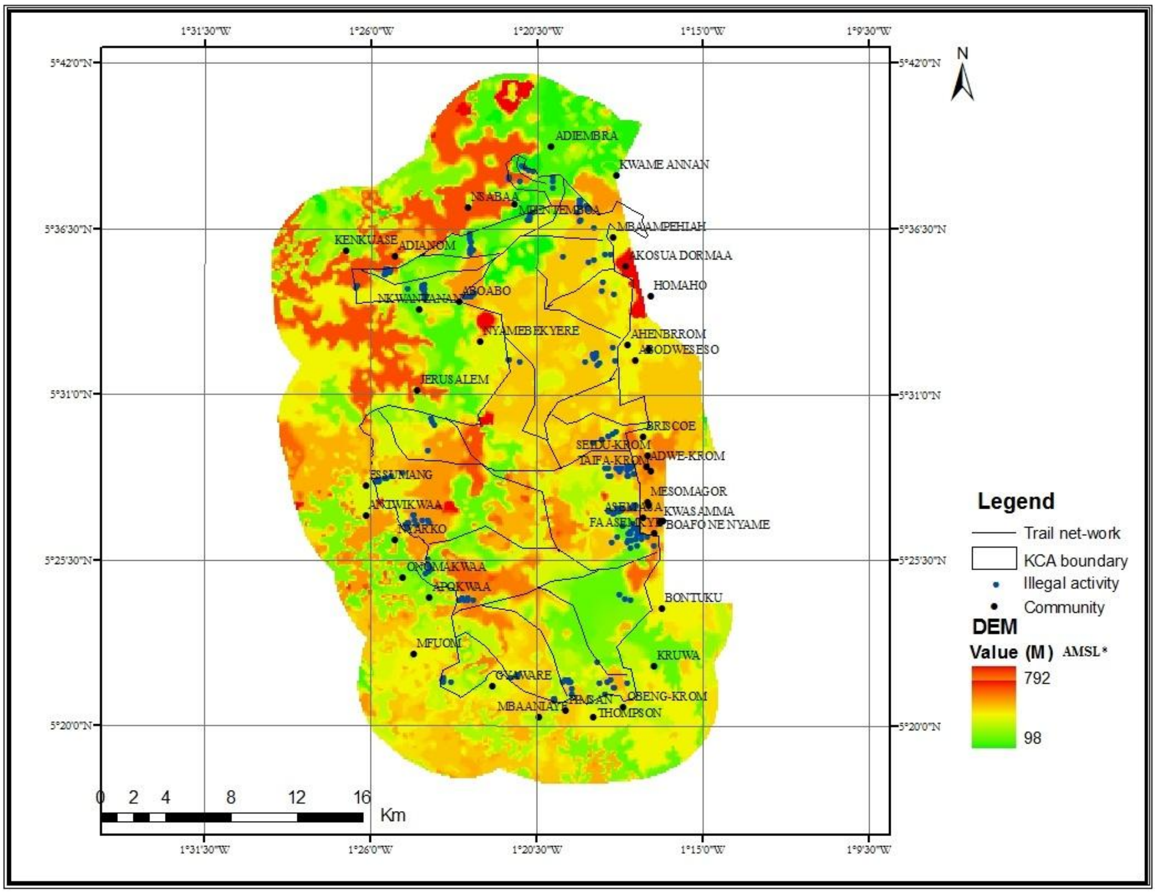

Figure 4.11: Elevation map of study area showing location of communities & illegal activities in KCA. *Above Mean Sea Level.

Effects of variations in mean elevation on the occurrence of illegal activities within KCA were therefore determined (Figure 4.11). Elevation map of KCA was derived from Digital Elevation Mode (DEM) using a spatial analyst tool in ArcGIS. Mean elevation in the study area ranges between 96—792m, with relatively high areas mostly occurring outside the borders of KCA. Illegal activities occurred at different mean elevations in the PA (Figure 4.12). Cutting of canes, rattans, vines, raphia palm and fuel-wood gathering occurred between the average heights of 100-180m above sea level, probably because these plant species have particular height at which they propagate. Cutting of sticks, settlements and tree markings occurred between the mean heights of 250-280m. Illegal activities that involved wildlife hunting in the PA occurred between the mean heights of 300-350m. Such activities include hunters' trails, spent cartridges, digging for rats and wire snares. Hence illegal activities within KCA occurred in all areas of the PA irrespective of differences in elevation, and thus implying that elevation has no influence whatsoever on occurrence of illegal activities in KCA.

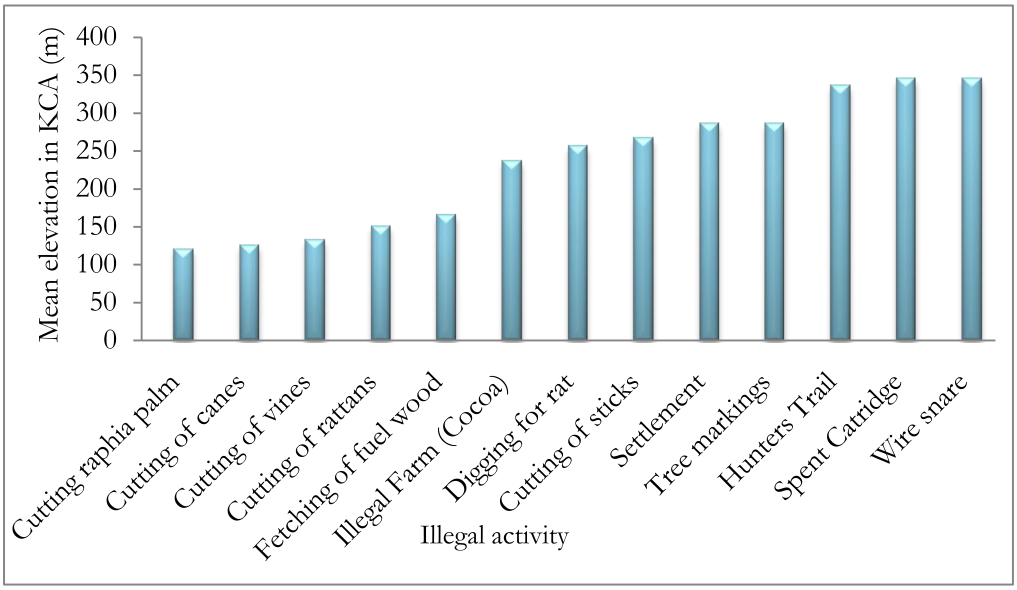

Figure 4.12: Mean elevation of illegal activities in KCA.

4.7. Effects of establishment of KCA on local livelihoods

Effects of the establishment of KCA on local livelihood were analysed based on responses from questionnaire surveys and official records from KCA as presented below:

4.7.1. Analysis of responses from questionnaire survey

Responses from field surveys showed that inhabitants around KCA, who are mainly farmers, constitute 2 groups of people; indigenes who are original citizens of the area and settlers who migrated from other regions of the country into the study area. The indigenous group constitutes 38%, whereas settlers form the majority with 62% of the total population in the study area. (Figure 4.13).

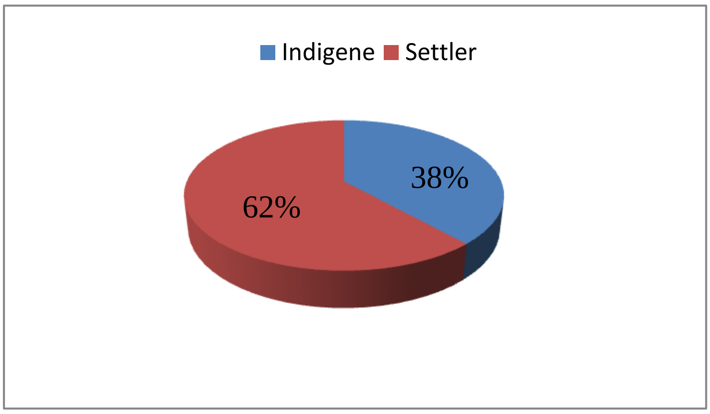

Figure 4.13: Proportions of indigenes and settlers around KCA.

The survey further revealed that the settler group comprises of 10 different tribes in the country who are indigenes in 7 out of the 10 regions. These revelations are further evidence of movement of people from other regions of the country into the study area. Ultimately high population growth rates around KCA resulted in the following scenario: (1) widened the people-PA frontier; (2) increased competition for available land and natural resources in the area; (3) loss of habitat due to land conversions; (4) increased human-wildlife conflicts and, (5) encroachment in KCA(Barnes *et al.,*2003; Eggert *et al.,*2003). Analyses of other responses generated from the questionnaire survey are shown in table 4.8.

Table 4.8: Analysis of responses generated from community surveys.

No.	Description	Frequency		Percent		Total(N)
		Yes	No	Yes	No	----------
1	Biodiversity conservation and wildlife knowledge	102	18	85%	15%	120
2	Ever collected products from Reserves	81	39	67.%	33.%	120
3	Suffer from wildlife depredations	110	10	92.0%	9.0%	120
4	Tangible benefits from PA	0	120	0	100%	120

Both groups of respondents are engaged in commercial and subsistence farming, mainly on the landscapes around KCA. Reported farm sizes range between 0.2ha—>14ha (Figure 4.14), with the average farm size ranging between 7.0—8.0ha for cocoa and 0.2—3.0ha for mixed crops.

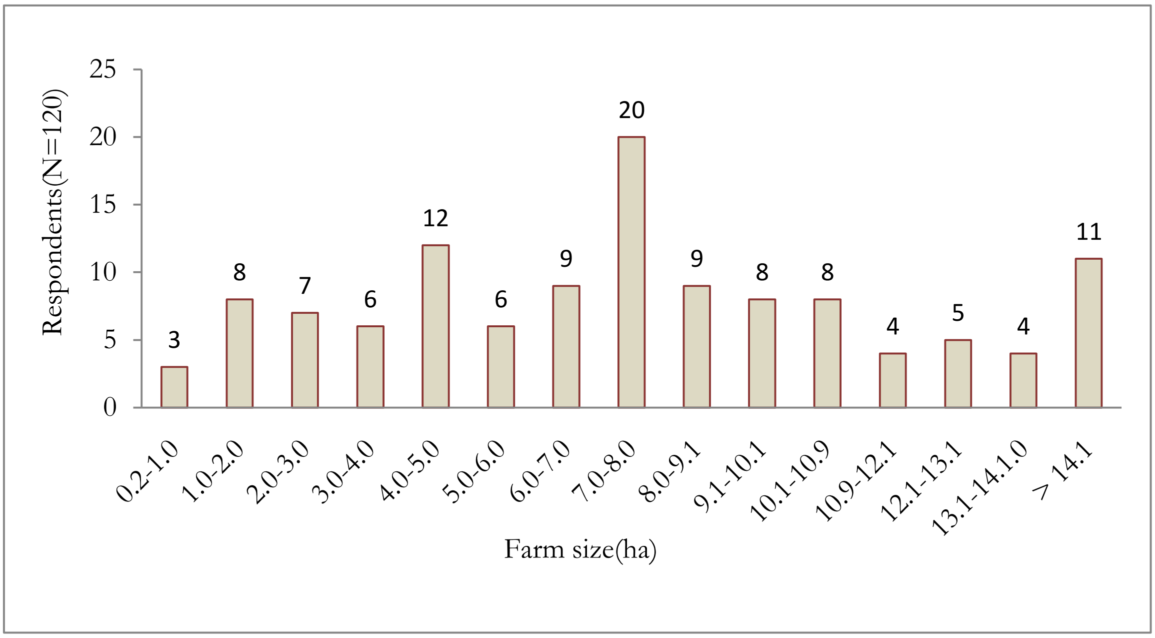

Figure 4.14: Distribution of farm sizes around KCA.

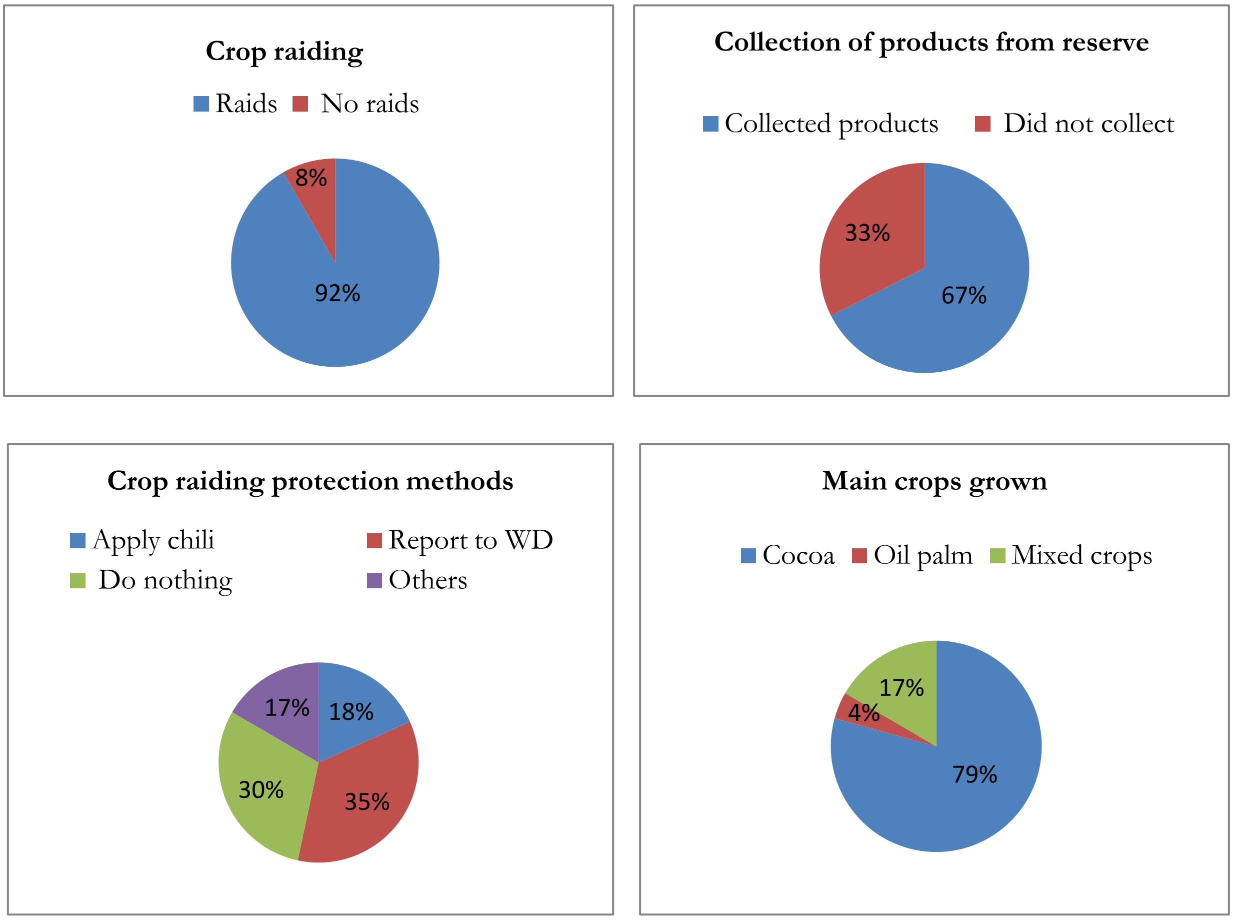

Figure 4.15: Percentage of respondents in relation to crops grown, collection of forest products, crop raiding & protection methods around KCA.

Cocoa is the major crop grown by farmers on landscapes that border KCA as was shown by the classified land cover map. Field surveys confirmed this fact with 79% of respondents involved in cocoa farming. It is followed by mixed crops with 17% and oil palm plantation 4% (Figure 4.15). 67% of respondents collected various products (NTFPs) from the forest, when it was not yet established as a PA, and hence had no restriction on access. The other 33% perhaps constitute the settler farmers who arrived in the area after KCA was established. According respondents some of the forest products collected were sold whereas some served as livelihood supplements for families. 92% of the respondents have once or more times suffered crop raiding on their farms by wildlife from KCA, with the elephant repeatedly mentioned as the main culprit in crop raiding. During group discussions respondents mentioned that although farmers suffered minor crop raiding from other species of wildlife from the PA, elephant raids are the most pervasive in the study area. Some locals are able to protect crops from elephant raids, 65% are either not willing or are not able for various reasons, and so lose their crops to elephants during each of the two cropping seasons in a year. Similarly, major concerns raised by respondents during interviews included crop raiding, inadequate land to cultivate more farms, financial challenges and loss of access to forest products. Of these concerns crop raiding was yet the most reported with 45.8%, followed by loss of forest products 37.5%, financial 2.5% and limited land 14.2% (Figure 4.16). During one of the key informant interviews it came out clearly that there is the problem of inadequate land for the locals to cultivate more farms because human population growth coupled with the desire to grow cocoa and oil palm generated competition for the resource. And as the adjoining land becomes scarcer the temptation for people to encroach on KCA becomes higher.

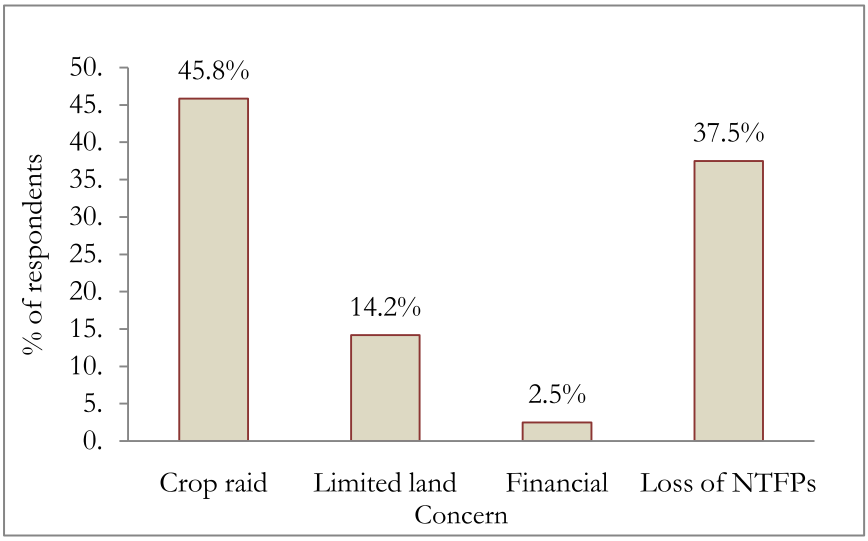

Figure 4.16: Major concerns of respondents.

4.7.2. Incidence of elephant crop raiding on landscapes around KCA

Respondents confirmed that farmers around KCA suffered elephant raids on farms during the period when KCA was not established. However frequency of crop raiding, number of farms affected as well as target crops increased after the establishment of KCA. Eggert *et al.* (2003) reported of the same findings in their research. Barnes *et al* (2003) inferred that increased reports of crop raiding in the study area are evidence of widened human-elephant interface due to increased human population. As a result of the situation 3 international organizations; the Food and Agriculture Organization (FAO), the WORLD BANK and the International Fund for Animal Welfare (IFAW) intervened in 2004, 2006 and 2008 in order to assist the farmers protect crops from elephant raids (Addo-Boadu, 2010; Monney *et al.,* 2010). Although farmers considered the interventions as a welcome relief, adoption rates are reportedly low among farmers mainly because of the cost involved in its application (Monney *et al.,* 2010). As such farmers on the landscape continue to experience elephant crop raiding (Figure 4.17).

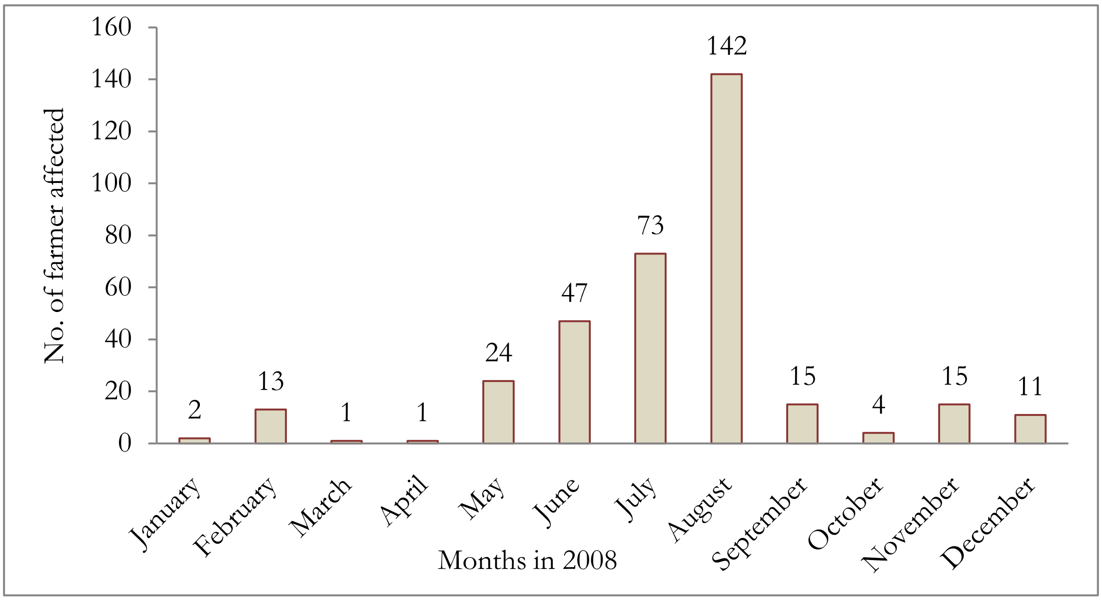

Figure 4.17: Occurrence of crop raiding around KCA in 2008.

Source: (Crop raiding report, KCA office 2008).

A total of 348 farmers suffered from crop raiding in 2008 (See appendix A.7 for elephant crop raiding summaries). Crop raiding is usually low at the beginning of the year and then picks up from May. The peak raiding months are June to August, sometimes up to September depending on rainfall patterns experienced in a particular year. Raids involved food crops such as maize, cassava, plantain, cocoyam to tree crops including cocoa and citrus.

5. DISCUSSION

5.1. Land-use/land cover classification of KCA and environs

Supervised classification of multi-spectral ASTER 2007 imagery was the main method used to determine land-use/land cover types in the study area. It is important in image classification to verify the output land-use/cover map by assessing its accuracy which is essentially a measure of how many ground truth pixels were classified correctly. The ASTER 2007 imagery classified the entire study area into five main land-use/cover types; built-up, cocoa, forest, mixed crops and plantation. However portions within the park area after classification showed the other 4 cover types, other than forest and since these areas could not be validated they were grouped and categorised as "disturbed forest". The classification yielded an overall accuracy of 83.53%, a little lower when compared to the 85% accuracy standard (Franklin *et al.,* 2003). The classification revealed that the study area is put under different land-use/cover types. Forest constitutes 43,764.8 ha (49.5%), cocoa farms 19,570.43 ha (22.1%), mixed crops14,686.18 ha (16.7%), oil palm plantations 4,505.06 ha (5.2%) built-up/bare 1,440.88 ha (1.6%) and areas described as "disturbed forest" in the PA 4,263.72 ha (4.9%).

5.2. Effects of habitat conversion on biodiversity conservation in KCA

Human disturbances within the PA as showed through the land cover map destroys habitats and leads to poaching of animals as noted from cartridge shells found along transects. Such disturbances also dissipate animals within the PA through destructions of territorial areas and drive them into the converted adjoining landscapes. Landscapes that adjoin PAs play important roles in sustaining ecological functions in and around PAs (Hansen & De-Fries, 2007). Such roles include serving as source areas for populations of species in the PA. Adjoining landscapes also serve as habitats for species with larger home ranges and migratory routes for particular species of fauna. In this regard the natural cross-boundary migration of flora and fauna species between KCA and the adjoining landscapes will be adversely affected (Wilkie *et al.,* 2006). This situation poses a further challenge to biodiversity conservation in the PA. Subsequently the natural ecological role of elephants and other large mammals as seed dispersal agents in and around KCA will be impacted as well (Blom *et al.,* 2004). The net effects is that the structure of forest species within KCA will change by favouring small-seeded trees over large-seeded, leading to lower diversity of trees that have big seeds in the PA.

5.3. Mean distances of communities and level of encroachment in KCA

Correlation coefficient, $R = -0.446$, $p < 0.004$ revealed negative relationship between mean distance of communities and illegal activities in KCA. $R^2 = 0.20$ at $p < 0.05$ (ANOVA, Single Factor). This implies that mean distance is only 20% accountable for the variance in illegal activities in KCA (the other 80% is due to other unexplained variables that need to be considered in future research). As a result relatively higher numbers of illegal activities were found along communities located between mean distances of 0.10—0.90km than along those located beyond 1km from the PA. This might be true in the sense that hunters who are farther from KCA may feel reluctant to travel longer distances to encroach for the fear of being noticed by neighbours and reported for arrest. This confirms the findings of Hofer *et al* (2000) who showed that poachers generally tend to avoid travelling long distances to hunt in PAs mainly for fear of being arrested. Wato & Okello (2006) however observed that in order to avoid being noticed for arrest poachers within long distances from a PA devised the tricks of travelling to settle temporarily in close by communities in order to execute their hunting expeditions from those communities.

5.4. Demographic characteristics of KCA

Comparison of population growth trends between 1984 and 2000 revealed that communities around KCA experienced more people during the period after its establishment. The total population of sampled communities in 1984 was 10,527 and this doubled to 21,749, in 2000. Further analysis of population growth showed a growth rate of 3.3% between 1970 and 1984 when KCA was not in existence, and 4.1% between 1984 and 2000 after KCA became established. This implies that human population growth rates went up by 0.8% after the establishment of KCA.

5.5. Population and levels of encroachment in KCA

Unlike distance the size of population in communities had a positive but insignificant relationship with levels of illegal activities in KCA, $R= 0.068$, $p > 0.0698$, $R^2=0.04$ at $p < 0.05$ (ANOVA, Single Factor). Thus population size is only 4% accountable for illegal activities in KCA. This implies that the more people there are within a local community the higher the level of encroachment in KCA, however at a very low, insignificant rate. Further analyses showed that communities with relatively large population sizes are invariably located between mean distances of 1.0—2.0km from the borders of KCA. Therefore mean distances of communities was found to be more accountable for the occurrence of illegal activities in KCA than size of population in communities. But mean distance alone may not be the only variable that contributes to the occurrence of illegal activities in the PA. Other variables that may include existence of logging roads, attitude of locals, seasonality and varying weather patterns among others would have to be taken into consideration holistically in analysing illegal activities within KCA.

The findings about the insignificant correlation between population size and illegal activities in the PA might be as a result of the fact that people in larger communities located farther from a PA as much as possible tend to avoid direct encroachment into KCA as compared to closer and smaller ones. It however does not mean closer communities are the ones solely responsible for all illegal activities in the PA for that matter. Experience has actually shown that larger communities' located distances away from PAs indirectly put pressure on PAs as well. This is through the substantial demands people in these communities have for forest products that includes bushmeat, fuel-wood, lumber, mortar and pestle among others. And so much of the forest products harvested from the PA by people who live close by are indirectly sent to meet demands of farther and relatively large urban communities which make such communities indirectly impact adversely on ecological functions in the PA. However extent of effects of farther and urbanised communities on the conservation of KCA needs to be researched.

5.6. Effects of KCA on community livelihood

Effects of KCA on local livelihoods could be discussed from two main points of view: 1) loss of access to land and forest products, 2) wildlife depredations on croplands.

5.6.1. Loss of access to forest products within KCA

Until the later part of 1989 the area that constitute KCA were forest reserves managed purposely for water catchment protection and timber production (Barnes *et al.,* 2003). As forest reserves the locals were allowed entry to collect assorted NTFPs. Forest products such as bushmeat, fish, fibres, berries and roots in particular served as food and dietary protein supplements, building materials for the construction of mud houses and medicinal plants for herbal health care needs. The source of such freely available ecosystem services ended from 1991 when KCA was established as a wildlife PA. 67%

of respondents reported of having collected forest products in the past for direct household consumption and also as source of income and employment. 37% of respondents identified loss of forest products from KCA as a major concern in its establishment. Human Development Index (HDI), developed by the United Nations Development Programme (UNDP) estimated that 90% of the world's poor depend on forests for at least a portion of their income (WORLD BANK, 2004; USAID, 2006). And in Africa 600 million people have been estimated to rely solely on forests and woodlands for their livelihoods (WRI, 2005). Shackleton & Shackleton (2004) remarked that depending on circumstances, forest products may offer both a "daily net" and a "safety net". The "daily net" describes everyday use, with products meeting current household needs, offering a reliable source of income for instance to pay for kids school fees or purchase agricultural inputs. A 'safety net' on the other hand comes into play when other sources of household income, for instance plantations fail to meet dietary shortfalls, or whenever a quick cash option is required (McSweeney, 2003). To this end loss of access to NTFPs in the case of KCA implies adverse effects on livelihoods of the locals, even though the net livelihood impacts are generally less easy to discern, as there is a lack of standardized assessment methodologies (Shackleton & Shackleton, 2004).

5.6.2. Wildlife depredations on croplands

Wildlife challenges encountered by communities living close to PAs fall into two main categories: damage to resources such as crop raiding and livestock predations, and threats to human life by wild animals from the PA. In the case of KCA however, the challenge is crop-raiding mainly by elephants migrating from the PA. This challenge was however identified as a symptom of the ecological changes that have taken place on landscapes bordering KCA, resulting from increased human populations in recent decades (Barnes *et al.,* 2003). According to Macdonald and Sillero-Zubiri (2002) larger animals such as forest elephants (*Loxodonta africana cyclotis*) typically require larger home ranges and more food resources to sustain a viable population. This causes them to extend their range beyond the limits of PA boundaries into neighbouring lands, thereby entering into conflicts with local communities. The scenario is the same with resident elephants in KCA. Responses from questionnaire showed that elephant raids were reported on farms in adjoining landscapes even before the establishment of KCA. However the frequencies and target crops increased after its establishment (Barnes *et al.,* 2003). Analyses of available records showed for instance that 348 farmers suffered elephant raids on farms around KCA in 2008. 92% of respondents during field work reported of ever experiencing elephant raids, once or twice in a year with almost all types of crops grown in the area prone to raids. Again 46% identified crop-raiding as a major concern regarding the establishment of KCA. Enormity of effects of crop raiding was lamented by community members during key informant interviews in the field. According to respondents a heap of cocoa pods in a farm could yield 4 maxi (62.5kg) bags of cocoa beans on average. A herd of elephants could destroy the heap overnight and impoverish the farmer and his dependants for the period. Crop raiding effects impacts more on the locals because the state does not compensate for wildlife depredations in the country. This is also because compensation scheme may end up attracting more migrants in to the area to re-fuel the very cause of the problem.

Aside from effects on the locals, crop raiding ultimately generates human-wildlife conflict scenarios that have had adverse affects on elephant conservation in KCA. When farmers are no longer able to contend with elephant problems on farms one available option is to consider eliminating the animals by shooting to kill. From the authors own experience there were instances in the history of KCA when an elephant was found killed by poachers almost every year. Investigations into such killings almost always revealed local farmers involvement, attributed mainly to crop raiding. This situation greatly affected the population of elephants and other species of mammals in the PA. The IUCN and the

World Wide Fund for nature (WWF) have instituted a mechanism to monitor the illegal killing of elephants in PAs dubbed, Monitoring Illegal Killing of Elephants (MIKE). And because of the elephant killing challenge in KCA it has since 2004 been used as one of the MIKE centres in the West African sub-region where illegal killing of elephants is monitored.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

In conclusion, the main findings of this research are in full support of the hypothesis that there is correlation between proximity of human activities to KCA and encroachment in KCA. Indeed the results found negative correlation between mean distance of communities and number of illegal activities in KCA. That is communities that are found closer to KCA tend to have higher levels of encroachment in KCA. However mean distances of communities was found to be only 20% accountable for the occurrence of illegal activities in the PA (the other 80% is due to other unexplained variables that need to be considered in future research). Unlike mean distance, the size of population in communities showed a positive but very insignificant correlation with illegal activities in the PA. In other words population size was found to be only 4% accountable for occurrence of illegal activities. Therefore higher human densities alone may not be the only variable responsible for illegal activities as reported by other studies. Mean distance of local communities and other variables such as existing logging roads, human attitudes, seasonality and varying weather patterns have to be considered holistically in analysis of illegal activities in PAs. Findings of the study also provided answers to the research questions that were posed as follows:

- ***What are the existing land-use/cover types around KCA?***

Classification of the multi-spectral ASTER 2007 imagery categorized the main land-use types on landscapes around KCA into 4 main classes. These are cocoa, oil palm plantation, mixed crops and built-up/bare. Cocoa constitutes the largest cover type on the fringes of KCA with a total area of 19,570.43 ha or 22.1%. It is followed by mixed crops representing 14,686.18 ha or 16.7%, oil palm plantations 4,505.06 ha or 5.2%, with the smallest land-use type around the PA being built-up/bare areas and covered 1,440.88 ha or 1.6%.

- ***What are the demographic characteristics of the study area?***

The total population of sampled communities in 1984 was 10,527 and this doubled to 21,749, in 2000. Further analysis of population showed a growth rate of 3.3% between 1970 and 1984 when KCA was not in existence, and 4.1% between 1984 and 2000 after KCA became established. This implies that human population growth rates went up by 0.8% after the establishment of KCA.

- ***How do the land-use types affect ecological functions and biodiversity conservation in KCA?***

Population growth on the fringes of KCA has resulted in varied uses of the landscape such as habitat conversion from forested to human dominated activities that include agriculture and settlements with diverse impacts on ecological processes in KCA. Change in land-use results in habitat conversion on the landscape that fringe KCA and by so doing affects the "zone of interaction" of KCA. The situation reduces effective size of habitats, affects source populations for species of fauna within the PA and eliminates migratory and foraging routes for species. In particular elephant populations and other large mammals within KCA will be severely impacted as a result of reduced home ranges due to habitat conversion. This research has also demonstrated that land-use and conversion is driven by population growth. In areas of KCA that are most adjacent to human dominated land-use the impacts are higher.

- ***What is the relationship between mean distance of communities and illegal activities in KCA?***

There is a negative relationship between mean distances of communities and number of illegal activities in KCA. The closer communities are to KCA the greater the level of illegal activities within their vicinities. However mean distance was found to be only 20% accountable for number of illegal activities in KCA.

- ***Can human activities around KCA serve as a basis for determining the level of encroachment in KCA?***

The results demonstrated that mean distance of communities is 20% accountable for number of illegal activities in KCA. This implies distance plays some role in the level of encroachment in the PA. Communities that are relatively close to KCA will normally encroach more than those that are farther away. Such communities will naturally cultivate farms close to the edges of the boundary and so convert more habitats and also depend more on KCA for building materials. Again communities with relatively large population sizes also showed positive relation with encroachment in the PA even though at a very low rate. Therefore by analysing locations of communities, farm plots as well as population trends in communities it is possible to draw fair conclusions on encroachment and impact levels in KCA.

- ***What are the effects of topography on illegal activities in KCA?***

Illegal activities within KCA were found to occur in all areas of the PA, irrespective of differences in mean elevation in the PA. Therefore elevation has no effects whatsoever on occurrence of illegal activities in KCA.

- ***What are the effects of establishment of KCA on local livelihoods?***

The results sufficiently showed that local livelihoods are adversely affected because of unattainable forest products and crop-raiding by wildlife from KCA. The magnitude of crop raiding effects on locals can be exemplified in the instance of a farmer who loses a whole season's produce to a herd of elephants overnight because he/she genuinely lacked the means to protect the crops from elephants. With no compensation for the loss and no access to products from KCA or alternative sources of livelihood, the farmer and his dependants are left impoverished for the period. In particular the lack of access to forest products in KCA implies that source of direct household income, consumption and employment have been affected adversely due to creation of KCA. Also traditional socio-cultural and religious ties with the forest as known of forest fringe communities are broken. Inaccessibility to bushmeat in particular results in reduced levels of dietary protein among families in the area or scarce cash will have to be spent to meet protein requirements. Consequently the severity of these effects on the locals breeds apathy and community/park conflicts that further make KCA highly unsustainable as biodiversity conservation area.

Arguably, KCA could be described as being responsible for accelerated human population growth on the fringes. This is because of the favourable ecological conditions the PA has since created on the bordering landscape that acts as a population "pull factor". At the same time KCA tends to "protect" itself from humans as elephant crop raiding makes it highly unsafe to grow crops on the fringes and therefore create more incentive for people to go away. In that case whoever chooses to reside and grow crops on the fringes should be prepared for the higher risks that are associated with it. Therefore compensation for crop loss should perhaps not be encouraged. The conservation risk however is that farmers may choose not to move away from the PA but resort to killing the elephants in order to save crops and livelihoods. A situation that has apparently, emerged around the PA in recent times.

In sum, it is obvious from the discussions so far, that establishment of KCA provides avenue for biodiversity conservation and ecosystem services at the global, national and local scale. However, the PA stands in danger of not being able to accomplish its conservation ambitions mainly because of accelerated human population growth on the fringing landscapes. Conflicts of interest over resource utilization between locals and park management, resulting from livelihood concerns and encroachment into KCA have all emerged as important biodiversity conservation issues as a result. The net effects are a challenging scenario of opposing adverse effects on the ecological processes in the PA and on local livelihood.

6.2. Limitations of the research

The following are limitations of the research:

- As a result of persistent clouds over the study area remote sensing imagery was not available for the years before the establishment of KCA. Analysis based on change detection of the study area could have improved upon the results of this research.
- The lack of current demographic data on local communities was a major challenge.

6.3. Recommendations

The following recommendations are made based on the research findings:

- This research considered mean distances of communities from KCA, elevation and population sizes on occurrence of illegal activities in KCA. Effect of other parameters such as existence of logging roads, human attitudes, seasonality and varying weather patterns in the study area should be considered in future researches of the area.
- Disturbed spots within the park area as revealed through land cover classification were labeled "disturbed forests". It is suggested that these spots are researched into in the future to determine the exact human activities that are taking place and measures instituted to discontinue such illegal activities.
- It is also recommended that researches in the future should take into consideration delineation of the exact spatial extent of ecological interactions (Zone of Interaction) between KCA and its surrounding landscapes, based on the biophysical and socioeconomic setting.
- Again future researches should consider the extent to which the current land-use types around KCA particularly cocoa, oil palm and mixed crops affect wildlife species abundance in them.
- Finally, it is recommended that management should identify opportunities in which ecological functions of KCA might continue to function with minimum negative consequences for local livelihood. Population growth trends and human activities as revealed through this research should serve as useful input material to determine the most effective management approaches in order to balance human needs with ecological functions within the PA. In particular efforts should be made to link local socioeconomic development with biodiversity conservation in KCA. This approach may go a long way to engender local community participation and a more collaborative relationship with KCA. In that regard putting in place interventions such as the provision of non-agricultural livelihood support schemes through the support of non-governmental organizations (NGOs) or through Integrated Conservation and Development Projects (ICDPs) as take place around PAs in other countries, will be a step in the right direction.

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8. APPENDICES:

Appendix A.1: CATEGORY AND SIZE OF PROTECTED AREAS IN GHANA

No.	Protected area	Size (ha)	% cover of Ghana	Vegetation type	Year gazetted
	National Parks				
1	Mole	448040	2.03	Tall Grass Savannah	1971
2	Digya	347830	1.46	Tall Grass Savannah	1971
3	Bui	182060	0.76	Tall Grass Savannah	1971
4	Kyabobo	35900	0.15	Montaigne Savannah	n/a*
5	Kakum	20700	0.09	Moist Evergreen Forest	1991
6	Nini-Suhien	16000	0.07	Wet Evergreen Forest	1976
7	Bia	7800	0.03	Transition Zone	1974
	Resource Reserves				
8	Gbele	56540	0.24	Tall Grass Savannah	1975
9	Ankasa	34300	0.14	Wet Evergreen Forest	1976
10	Kalapka	32000	0.13	Short Grass Savannah	1975
11	Bia	28800	0.10	Moist SemiDe./Evergreen	1974
12	Assin Attandaso	13970	0.06	Moist Evergreen Forest	1991
13	Shai Hills	4860	0.02	Short Grass Savannah	1971
	Strict Nature Reserve				
14	Kogyae	38570	0.16	Tall Grass Savannah	1976
	Wildlife Sanctuaries				
15	Bomfobiri	5310	0.0223	Tall Grass Savannah	1975
16	Owabi	1310	0.0055	Moist Semi-De. Forest	1971
	Coastal Wetlands/Ramsar Sites				
17	Anlo-Keta	100000	0.4	Coastal wetland	1993
18	Songor	51100	0.2	Coastal wetland	1993
19	Muni-Pomadze	1500	0.006	Coastal wetland	1993
20	Densu Delta	5900	0.02	Coastal wetland	1993
21	Sakumo	1450	0.006	Coastal wetland	1993
	Total	1,432,940	6.2%	---------------	------------

Appendix A.2: IMAGE PROJECTION SYSTEM

Projected Coordinate System: Legion_Tranverse_Mercator

Projection: Transverse Mercator

False_Easting: 274319.739000

False_Northing: 0.0000000

Central_Meridian: -1.0000000

Scale_Factor: 0.99975000

Latitude_Of_Origin: 4.66666667

Linear Unit: Meter (1.000000)

Geographic Coordinate System: GCS_Leigon

Angular Unit: Degree (0.017453292519943299)

Prime Meridian: Greenwich (0)

Datum: D_Leigon

Spheroid: Clark_1880_RGS

Semimajor Axis: 6378249.144999999600000

Semiminor Axis: 6356514.8695497755000000

Inverse Flattening :293.46499999999970000

Appendix A.3: CONFUSION MATRIX OF ERRORS FOR CLASSIFICATION

	References					
	Forest	Plantation	Mixed Crops	Cocoa Farm	Built -up	Totals
Forest	79	1	5	2	2	89
Plantation	2	16	1	3	0	22
Mixed crops	3	1	60	6	2	72
Cocoa Farm	4	2	3	45	1	55
Built-up/bare	1	1	1	1	13	17
Totals	89	21	70	57	18	255

----- End of Error Matrix ----

KAPPA (K^) STATISTICS

Overall Kappa Statistics = 0.7776

Conditional Kappa for each Category.

Class Name	Kappa
Forest	0.8274
Plantation	0.7028
Mixed Crops	0.7703
Cocoa Farms	0.7658
Built-up/bare	0.7468

----- End of Kappa Statistics -----

Appendix A.4: SUMMARY OF POPULATION GROWTH TRENDS AROUND KCA (1970-2000)

	Community	Population in 1970	Population in 1984	Population in 2000	Annual growth Rate(%)(1984-2000)
1	Aboabo	91	225	532	8.5
2	Abodweseso	167	287	976	15
3	Adianum	40	83	299	16.2
4	Adiembra	1,123	1,456	1,987	2.2
5	Adwe-Krom	n/a*	123	543	21.3
6	Ahenbrom	440	668	1,988	12.3
7	Akosua-Dorma	139	298	432	2.8
8	Antwikwaa	67	284	479	4.2
9	Apokwaa	n/a	32	184	29.6
10	Asem Asa	115	370	593	3.7
11	Boafo Yena	26	312	718	8.1
12	Briscoe	32	178	389	7.4
13	Bunkutu	80	198	206	0.2
14	Essuman	98	71	243	15.1
15	Fa Asem kye	74	255	421	4
16	Gyahadzi	n/a	56	76	2.2
17	Gyaware	32	56	107	5.6
18	Homaho	105	722	1,182	3.9
19	Jerusalem	n/a	52	156	12.5
20	Jerusalem-Ahen	n/a	41	98	8.6
21	Kenkuase	185	201	431	7.15
22	Kruwa	785	954	1,972	6.6
23	Kwame Annan	12	87	189	7.3
24	Kwassama	31	69	196	11.5
25	Mbaampehiah	21	90	379	20.07
26	Mbaaniaye	72	187	365	5.9
27	Mesomagor	109	216	395	5.1
28	Mfuom	867	1,463	2,910	6.1
29	Mpentemboa	n/a	98	56	-2.6
30	Nkwantanaan	52	101	398	18.3

31	Nsabaa	n/a	167	108	-2.2
32	Nyamebekyere	105	142	945	35.3
33	Nyame-Nti	311	432	664	3.3
34	Nyarko	72	129	203	3.5
35	Obengkrom	44	87	156	4.9
36	Onomakwaa	43	98	244	9.3
37	Pimsane	45	56	145	9.9
38	Seidukrom	43	64	86	2.1
39	Taifa-Krom	n/a	42	109	9.9
40	Thompson	n/a	74	189	9.7
	Totals	5,461	10,524	21,749	AAGR* 8.9%

* n/a, no data available; * AAGR, Average Annual Growth Rate
Source: Population and Housing Census,(Volumes) 1970, 1984 & 2000 (GSS)

Appendix A.5: RESULTS FROM STATISTICAL ANALYSIS

(i) Correlation between distance of communities and illegal activities

Correlation			
		distance	Illegal activity
distance from PA	Pearson correlation	1	-0.446
	Sig. (2-tailed)*		0.004
	(N)	40	40
Illegal activity	Pearson correlation	-0.446	1
	Sig. (2-tailed)	0.004	
	(N)	40	40

*correlation is significant at 0.05 level (2-tailed).

Regression statistics

Regression Statistics	
Multiple R	0.45
R Square	0.20
Adjusted R Square	0.18
Standard Error	0.49
Observations	40.00

Regression analysis

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	1.23	0.16	7.81	0.00	0.91
No. of illegal activities	-0.07	0.02	-3.07	0.00	-0.12

(ANOVA, Single Factor)

	df	*SS*	*MS*	*F*	*F Sig.*
Regression	1.00	2.28	2.28	9.43	0.00
Residual	38.00	9.18	0.24		
Total	39.00	11.45			

(ii) Correlation between population and illegal activities

Correlations			
		Population in 2000	Illegal activities
Population in 2000	Pearson Correlation	1	0.068
	Sig. (2-tailed)*		0.698
	N	40	35
Illegal activities	Pearson Correlation	0.068	1
	Sig. (2-tailed)	0.698	
	N	40	40

* Correlation significant at 0.05 level (2-tailed

Model summary

Model Summary					
Model	r	r^2	adjusted (r) square	Std. error of the estimate	change statistics (r)square change
	0.068058129	0.04631909	0.02553076	3.49376608	0.0463191

(ANOVA, Single Factor)

ANOVA					
	Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*
Regression	1.87	1	1.87	0.15	0.70
Residual	402.81	38	12.21		
Total	404.69	39			

a. Predictors: (constant), population in 2000

b. Dependent Variable: illegal activities

Appendix A.6: Summary of Population, mean distance and illegal activities

	Community	Population in 2000	(%)	Distance from PA(km)	Illegal activities	(%)
1	Aboabo	532	2.4	0.2	17	7.2
2	Abodweseso	976	4.5	1.0	3	1.3
3	Adianum	299	1.4	0.8	15	6.4
4	Adiembra	1,987	9.1	1.5	3	1.3
5	Adwe-krom	543	2.5	0.4	7	3.0
6	Ahenbrom	1,988	9.1	1.0	4	1.7
7	Akosua-dorma	432	1.9	0.5	5	2.1
8	Antwikwaa	479	2.2	0.5	12	5.1
9	Apokwaa	184	0.8	0.6	8	3.4
10	Asem Asa	593	1.9	0.5	5	2.1
11	Boafo Yena	718	3.3	0.2	6	2.6
12	Briscoe I	389	1.8	0.1	6	2.6
13	Bunkutu	206	0.9	1.3	3	1.3
14	Essuman	243	1.1	0.2	7	3.0
15	Fa asem kye	421	1.9	0.3	9	3.8
16	Gyahadzi	76	0.3	0.1	7	3.0
17	Gyaware	107	0.5	0.7	4	1.7
18	Homaho	1,182	5.4	1.0	3	1.3
19	Jerusalem	156	0.7	0.7	4	1.7
20	Jerusalem-Ahen	98	0.5	1.0	2	0.9
21	Kenkuase	431	1.9	2.3	3	1.3
22	Kruwa	1,972	9.1	1.8	1	0.4
23	Kwame annan	189	0.9	1.0	6	2.6
24	Kwassama	196	0.9	1.4	3	1.3
25	Mbaampehiah	379	1.7	0.6	5	2.1
26	Mbaaniaye	365	1.7	1.1	4	1.7
27	Mesomagor	395	1.8	0.7	7	3.0
28	Mfuom	2,910	134	1.8	5	2.1
29	Mpentemboa	56	0.3	0.1	5	2.1
30	Nkwantanaan	398	1.8	0.8	12	5.1
31	Nsabaa	108	0.6	0.9	10	4.3
32	Nyamebekyere	945	4.4	2.0	4	1.7
33	Nyame-nti	664	3.2	0.2	5	2.1

34	Nyarko	203	0.9	0.2	6	2.6
35	Obengkrom	156	0.7	0.3	8	3.4
36	Onomakwaa	244	1.3	0.5	5	2.1
37	Pimsane	145	0.7	1.0	5	2.1
38	Seidukrom	86	0.4	0.9	5	2.1
39	Taifa-krom	109	0.5	1.0	4	1.7
40	Thompson	189	0.9	1.4	2	0.9
Total		21,749	100	--------	233	100

AppendixA.7: SUMMARY OF CROP RAIDING INCIDENCE

Month	No. of farmers affected	Percentage (%)	Mean
January	2	0.6%	0.17
February	13	3.7%	1.08
March	1	0.3%	0.08
April	1	0.3%	0.08
May	24	6.9%	2.00
June	47	13.5%	3.92
July	73	20.9%	6.08
August	142	40.8%	11.83
September	15	4.2%	1.25
October	4	1.1%	0.33
November	15	4.3%	1.25
December	11	3.4%	0.92
Total	348	100%	--------

Appendix A.8: ANALYSIS OF QUESTIONNAIRE SURVEY

	Description	Frequency	Percent	Total(N)	Percent	Mean
1	Crops grown					
	Cocoa	81	68%			0.67
	Oil palm	11	9%			0.09
	Mixed crops	28	23%	120	100	0.23
2	Use of forest products					
	Sold	35	29.2%			0.29
	Household sup.	85	70.8%	120	100	0.70
3	Category					
	Indigenes	46	38.3%			0.38
	Settlers	74	61.7%	120	100	0.62
4						
		77	64%			0.64
		37	30.8%			0.30
	Constraints faced	6	5%	120	100	0.05
5	Crop protection methods used	22	18%	120	100	0.18
		42	35%			0.35
		20	17%			0.16
		36	30%			0.3