POPULATION STATUS AND HABITAT SUITABILITY FOR MOUNTAIN BONGO (*Tragelaphus eurycerus isaaci,* Ogilby, 1837) IN CHERANGANI HILLS, KENYA

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DECLARATION

Declaration by the Candidate

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Declaration by Supervisors

This Thesis has been submitted for examination with our approval as University Supervisors.

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DEDICATION

This thesis is dedicated to my family.

ABSTRACT

Mountain bongo (*Tragelaphus eurycerus isaaci*) is one of the critically endangered large forest antelope currently endemic to mountain forests of Kenya. Its population status in some of these forests, including Cherangani hills, is unknown. Mountain bongo population is on decline due to poaching for meat and degradation of their fragile habitats. Forest in Cherangani hills has faced degradation. The study sought to determine the population status of mountain bongo and suitability of the Cherangani hills for mountain bongo survival. To achieve this, four methods were used. First, remote sensing tools and GIS were used to analyze the habitat suitability based on five parameters: land cover, slope, altitude, saltlicks and security that favour mountain bongo survival. Second, structured questionnaires were used to collect information on the relationship between local community and the conservation and management of forest resources where 100 respondents were systematically selected and interviewed. Third, reconnaissance walks were carried out for direct or indirect sightings and to assess human disturbance in Kapolet and Kipkunur forests. Lastly, 18 camera traps were mounted and left for three months in Kapkanyar and Kipkunur forests. The results showed that the majority of local communities (98.6%) were aware that mountain bongo had seriously declined in Cherangani hills with forest destruction (56.8%) and poaching (35.8%) being the major drivers. Despite the local community's admitting of mountain bongo presence (73.76%, n=95) in the area, camera trapping or reconnaissance walks did not indicate the presence of mountain bongo. However, the suitability assessment showed that good (197.37 km^2) and optimum (261.79 km^2) habitats still exist in Cherangani hills that can support up to 114 mountain bongos. It is regrettable that indigenous forest had significantly declined in coverage (R^2=0.690, P=0.041) between 1973 and 2011, despite this land cover type making a good portion of good habitat (80.98%) and optimum habitat (100%). In relation to this, a significant loss of good mountain bongo habitat (R^2=0.708, P=0.036) has been experienced between 1973 and 2011. Nevertheless, forests in Cherangani hills are still rich in biodiversity. The study concludes that: (i) the local communities had ample knowledge on mountain bongo and forest status, (ii) no presence of mountain bongo was confirmed in Cherangani hills and (iii) a suitable mountain bongo habitat exists. Since the locals relied on natural forest products, the study recommends that the locals be provided with alternative source of income. More research needs to be undertaken to explore on the feasibility and requirements for re-introduction of the mountain bongo in Cherangani hills.

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LIST OF ACRONYMS

AHP	Analytical Hierarchy Process
AZA	Association of Zoos and Aquariums
BSP	Bongo Surveillance Programme
CBSG	Conservation Breeding Strategy Group
CDM	Carbon Development Mechanism
CITES	Convention for International Trade of Endangered Species of Flora and Fauna
DEM	Digital Elevation Model
DRSRS	Department of Resource Survey and Remote Sensing
DSM	Distribution Species Model
GIS	Geographical Information System
GoK	Government of Kenya
GPS	Geographical Positioning System
IBM	International Business Machine Corporation
ILRI	International Livestock Research Institute
ILWIS	Integrated Land and Water Information System
IUCN	International Union for Conservation of Nature (The World Conservation

	Union)
IUCN/SSC	International Union for Conservation of Nature / Species Survival Commission
KFS	Kenya Forest Service
KWS	Kenya Wildlife Service
MDNR	Minnesota Department of Natural Resources
REDD	Reduction of Emission from Deforestation and Degradation
RS	Remote Sensing
SMCE	Spatial Multi Criteria Evaluation
SPSS	Statistical Package for Social Science
TM	Thematic Mapper
UNEP	United Nations Environment Programme
USA	United States of America
USGS	United States Geographical Survey

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CHAPTER ONE

INTRODUCTION

1.1. Background information

Mountain or Eastern Bongo (*Tragelaphus eurycerus isaaci*) is one of the largest forest *Tragelaphine* antelope sub-species which is endemic to mountain forests of Kenya (CBSG, 2010; Faria *et al.*, 2011). The species went extinct in Uganda in 1913 (Faria *et al.*, 2011). Currently, the Kenyan mountain bongo subpopulations are found in Aberdare, Mount Kenya, Mau and Eburu, with unknown status in Cherangani hills, Mount Elgon and Londiani where it used to exist (Price, 1969; CBSG, 2010; Bosley, 2010).

In the last few decades, there has been a rapid decline in the numbers of Mountain bongo in the wild due to bushmeat trade, disease and habitat loss (Estes *et al.*, 2008; Faria *et al.*, 2011). Despite this, no clear documentation of the population sizes of various sub-populations is available, though figures stand at less than 100 individuals mainly confined to the Aberdare (Estes *et al.*, 2008; CBSG, 2010). A reintroduction of 18 individuals to Mount Kenya Wildlife Conservancy was done in 2004 from Association of Zoos and Aquariums (AZA) facility in the USA meant to re-establish a viable and self sustaining population in the native habitat of the species (CBSG, 2010).

According to IUCN/SSC Antelope Specialist Group, Mountain bongo is classified as critically endangered (IUCN, 2011) with more specimens in captivity than in the wild (Faria *et al.*, 2011). As at December 31, 2007, about 560 individuals existed in 119 zoos worldwide (Wright *et al.*, 2011). CITES (Convention for International Trade for Endangered species of Flora and Fauna) has put it under appendix III which allows limited trade on the species but in Kenya the species is protected by a total ban on hunting (CBSG, 2010). Due to its charismatic and endangered status, mountain bongo qualifies to be a flagship species that need to be used to attract public concern and support for research and conservation (CBSG, 2010). Estes *et al.,* (2008) argued that the species can also be an umbrella species due to its prime habitat occupation – the water towers.

1.2. Statement of the problem

The local community that live close to or in the periphery of forests (e.g. Cherangani hills) depends on the forests for most of their needs for fuel wood, poles and thatching materials used in construction of houses and grazing (Estes *et al.,* 2008; Birdlife International, 2012; Evangelista *et al.,* 2012). As the human population outside the forest increases, pasture land diminishes and pressure on the forest products demand rises (Estes *et al.,* 2008; Birdlife International, 2012; Evangelista *et al.,* 2012). Forests in Cherangani hills are not shielded from these pressures (Birdlife International, 2012). These pressures may have contributed to the decline of mountain bongo habitat and maybe the reason for the declaration in some literature that the Cherangani hills subpopulation is locally extinct (BSP, 2010; CBSG, 2010).

The population status of mountain bongo of Cherangani hills is unknown (BSP, 2010; CBSG, 2010; Birdlife International, 2012). Prettejohn (2008) is skeptical about the existence of mountain bongo in Cherangani hills, though some remnant forest in Cherangani still needs to be explored. To make the situation worse, no local knowledge has been documented about the mountain bongo. For sure, there is wealth of indigenous knowledge about the biodiversity of an area and thus understanding the traditional uses and perceptions of a species like mountainbongo, can be useful for conservation planning (Doggart, 2006; Evangelista *et al.*, 2012). It is also necessary to note that, the suitability of the remaining forest in Cherangani hills as a mountain bongo habitat is unknown. This means, there is a huge gap in knowledge about Cherangani hills especially its potential for mountain bongo's current and future survival.

1.3. Justification of the study

The data gathered during the study forms baseline information that is relevant to understanding the status of Cherangani hills mountain bongo and its habitat. This information is relevant to the country's wildlife custodian: The Kenya Wildlife Service as well as Kenya Forest Service and antelope specialist groups. The results of the study would shed some light on the species status and survival in Cherangani hills. Evidence of presence of mountain bongo or availability of mountain bongo suitable habitat in Cherangani hills helps in restoration and conservation of the encroached and deforested Cherangani hills water tower: one of the five important Kenyan water towers (GoK, 2007). This should lead to the development of a holistic management plan for conservation of forest and specific initiatives for mountain bongo protection and management. Also local communities will be educated on how to develop tourism related ventures that will reduce their dependence on the forests resources. Availability of suitable habitat for the mountain bongo, would call for lobbying for restocking or establishment of a breeding sanctuary. This is in line with the mountain bongo national conservation strategy that targets to sustain a population size of at least 20 individuals in Cherangani hills over the next 50 years starting 2010 (CBSG, 2010).

Kenya is transiting to county governance from centralized governance. The information from this research would assist in decision-making and development of conservation policies within the counties (Marakwet, Trans Nzoia and West Pokot). This will guide conservation priorities in the relevant counties.

1.4. Research objectives

1.4.1. Main objective

The aim of the study was to determine the population status and the suitability of the Cherangani hills for the survival of the mountain bongo.

1.4.2. Specific objectives

2. To quantify the land cover change in Cherangani hills between 1973 and 2011.
3. To determine the remaining suitable habitat for mountain bongo in Cherangani hills.
4. To determine the mountain bongo suitable habitat change between 1973 and 2011.
5. To estimate the carrying capacity of mountain bongos in Cherangani hills.
6. To document indigenous knowledge on mountain bongo and forest status in Cherangani hills.
7. To determine if mountain bongos still exist in Cherangani hills
8. To identify large wild herbivores and carnivores in Cherangani hills.

1.5. Research questions

To address the specific objectives, the following questions were formulated;

1. How has land cover changed in Cherangani hills for the last 40 years?
2. How much of the habitat in Cherangani hills is suitable for mountain bongo?
3. Has the mountain bongo habitat changed for the last 40 years?

4. What is the carrying capacity of mountain bongos in Cherangani hills?
5. What is the level of local people's knowledge about the mountain bongo and forest status in Cherangani hills?
6. Are there mountain bongos in Cherangani hills?
7. Which large wild herbivores and carnivores are present in Cherangani hills?

1.6. Scope of the study

The study area targeted Cherangani hills covering partly to North of Elgeyo Marakwet, East of Trans Nzoia and South of West Pokot counties. Marich pass forms the northern boundary, Kapenguria to west, Uasin Gishu to south and Elgeyo escarpment to the east. It is in this area that land cover mapping and change, mountain bongo population status, mountain bongo habitat suitability and local community knowledge was conducted.

CHAPTER TWO

LITERATURE REVIEW

2.1. Cherangani hills

Prime habitats that host most of the threatened species face degradation and fragmentation due to increase in human population and demand for food supply (unsustainable poaching) which have driven most of these species to local extinction (Nazeri *et al.,* 2010; Evangelista *et al.,* 2012). When habitats are reduced, species diversity decreases and this is made worse when information on threatened species is scarce (Nazeri *et al.,* 2010; Evangelista *et al.,* 2012). This calls for the need to assess these ecosystems and species if conservation and management has to succeed (Evangelista *et al.*, 2012).

Forests in Cherangani hills are one of the prime habitats that are believed to host one of the critically endangered species: the mountain bongo, but has suffered deforestation and fragmentation (Birdlife International, 2012). Over the last 20 years, local inhabitants have encroached on the forest land converting it to farmlands (GoK, 2007). Studies carried out in 2000-2003 by UNEP (United Nation Environment Programme) and DRSRS (Department of Resource Survey and Remote Sensing) showed that the change in forest cover was relatively low compared to other water towers because most of the forests in Cherangani hills are mostly indigenous. For Cherangani hills, about 174.3 hectares have been deforested (GoK, 2007). Because most of the forest cover in Cherangani hills is indigenous, it was recommended that the area to be closely watched over to prevent further destruction (GoK, 2007). The greatest loss was reported to have occurred in Marakwet district and West Pokot District.

Among the threats facing forests in Cherangani hills include encroachment, degazettement, poaching of trees for building or charcoal production, livestock grazing, tree-felling by honey gatherers (for honey, or for manufacturing bee hives) and occasional fires, possibly started by honey gatherers (Birdlife International, 2012). These threats pose direct impacts on the survival of mountain bongo in Cherangani hills. There is urgent need to protect and conserve this critical habitat to ensure long term survival of the biodiversity.

2.2. Land cover mapping and change detection

Land cover change is the modification of the earth's surface features by humans that is triggered by human search for food and other essentials for years which can be at local, regional or global scales (Frimpong, 2011). Change detection therefore involves identifying differences in the state of land cover by observing it at different times (Lu *et al.,* 2004). Timely and accurate change detection of earth's surface features provides clear understanding of the relationship and interactions between humans and natural phenomena to better manage and use resources (Lu *et al.,* 2004).

Land cover monitoring can be an expensive and time consuming exercise especially in ground surveys conducted for validation of data (Kuria *et al.,* 2010; Varjo, 1995). Remote Sensing (RS) is the new technology that counters this shortcoming (Kuria *et al.,* 2010). Remote Sensing is a process of acquiring information about the Earth's surface without actually being in contact with it (Frimpong, 2011). The method senses and records energy that is reflected or emitted by the earth feature which can be processed, analyzed and information applied (Frimpong, 2011). Aerial photography is one of the type of RS that provide geometrically accurate maps but limited on the area of coverage (Kuria *et al.*, 2010). Satellite imagery is currently popular due to its regular and frequent data collection which is cheaper and covers a large area (Kuria *et al.,* 2010). The energy sensed is recorded in form of digital numbers that range from 0 to 255. The digital numbers are classified into land cover types and are also used to monitor land cover changes (Kuria *et al.,* 2010).

Change detection can be monitored using various techniques namely image differencing, image rationing, image regression and change vector analysis (Lu *et al.,* 2004; Berberoglu and Akin, 2009; Kuria *et al.,* 2010). Each of these methods has its own merits and demerits (Lu *et al.,* 2004; Berberoglu and Akin, 2009) but they all provide simple detection of change which is rarely sufficient in itself (Kuria *et al.,* 2010). In summary, these methods do not give information on initial and final land cover types that can be quantified (Kuria *et al.*, 2010). A good change detection research therefore should be able to provide area change and change rate, spatial distribution of changed types, change trajectories of land cover types and accuracy assessment of change detection results (Lu *et al.,* 2004). It is therefore necessary to do image classification (supervised) which can be quantified on the respective land cover types especially where details of 'from-to' is required (Lu *et al.,* 2004).

2.3. Habitat suitability models

Species have specific requirements based on behaviour, biology, genetics and evolutionary history. These combined allow them to choose suitable habitats for survival and each habitat should provide these requirements (Nazeri *et al.,* 2010). Understanding species requirements makes it easy to define suitable habitats for a species. Habitat suitability models can also be used to predict species distribution, locating species of concern, predicting suitable habitat of a species which is not utilized, aid in species re-introduction or predict spread of an introduced species, predicting species richness, presence or absence of species, probability of species occurrence or index of habitat suitability of a species (Nazeri *et al.,* 2010). The habitat suitability models have shortcomings since it is not only habitat that determines species survival but other factors like species interactions (inter-specific and intra-specific) should be considered (Nazeri *et al.,* 2010).

Use of remote sensing techniques is essential in developing models that yield clear relationship between a species and its habitat (Nazeri *et al.*, 2010; Evangelista *et al.*, 2012). What is basically needed for the models is gathering of species field data and monitoring environmental factors by use of remote sensing images and Geographical Information Systems (GIS) layers (Nazeri *et al.,* 2010; Evangelista *et al.*, 2012).

Field data may be scanty and thus use of qualitative information (expert knowledge) is the best approach for quantifying the relationship between a species and the environment (Evangelista *et al.,* 2012). Expert knowledge can be provided by wildlife managers, researchers, hunters, local knowledge or scientific literature and can then be used with geospatial tools to develop expert-based habitat models (Salvatori *et al.,* 2006; Evangelista *et al.,* 2012).

Habitat change can quickly be monitored by developing geospatial maps of habitat for specific species (Evangelista *et al.*, 2012; Nazeri *et al.*, 2010). Traditional methods for monitoring habitat has been limiting especially for inaccessible areas like intact forests. However, the use of remote sensing, Geographical Information Systems (GIS) and Geographical Positioning System (GPS) along with Distribution Species Models (DSM) provide efficient methods that help to determine habitat suitability and quality (Estes *et al.*, 2008; Estes *et al.*, 2010; Nazeri *et al.*, 2010; Evangelista *et al.*, 2012). Remote sensing provides accurate and reliable input data for species distribution models and is also credible in monitoring habitat changes caused by either natural or human processes over temporal scales (Nazeri *et al.*, 2010; Evangelista *et al.*, 2012).

2.4. Mountain bongo classification, conservation and population status

The classification of mountain bongo has been challenging. It is known to be the only spiral-horned antelope with both sexes having horns (Bosley, 2010). The species was first classified in their own genus (*Boocercus*), later, same as eland (*Taurotragus*) and now *Tragelaphus* (Bosley, 2010).

Bongo comprises of two sub-species; mountain bongo (Eastern) (*Tragelaphus eurycerus isaaci*) and lowland bongo (Western) (*Tragelaphus eurycerus eurycerus*) (Bosley, 2010; BSP 2010 & 2011). Mountain bongo’s historical range is mountain forest of Kenya and Uganda (Ralls, 1978; Bosley, 2010). However, the Ugandan subpopulation went extinct in 1913 (Bosley, 2010; CBSG, 2010; Faria *et al.*, 2011). Lowland bongo occupies the lowland equatorial forest of west and central African countries and some extend to southern Sudan (Bosley, 2010; BSP, 2010 & 2011).

Currently, mountain bongo is restricted to the mountain forests in Kenya though their exact numbers are not clearly known but estimates are available (CBSG, 2010). This is common in developing countries where resources are limited for monitoring rare or endangered species (Evangelista *et al.,* 2012). Mountain bongo adult population on the various mountain forests in Kenya does not, however, meet the IUCN threshold of at least 45 adult individuals per forest (Bosley, 2010; IUCN, 2011). Even when are combined, their populations does not go beyond 250 individuals in the wild (CBSG, 2010; Bosley, 2010; Wright *et al.,* 2011).

Mountain bongo population sizes in some mountain areas in Kenya have been estimated to range from 75-140 for Aberdare, Mt. Kenya, Mau and Eburu forests (Bosley, 2010; CBSG, 2010). Population status of other mountain forests in Kenya is not known (CBSG, 2010). The mountain bongo population is believed to be in drastic decline. This has been attributed to bushmeat trade, disease, predation and habitat loss (Estes *et al.,* 2008; CBSG, 2010; Faria *et al.,* 2011). Poaching mountain bongo for meat, horn and skin has been documented (Ralls, 1978; Kingdon, 1997) but even current reports show poaching is still being practiced (Bosley, 2010, BSP, 2010 & 2011). Bongos are susceptible to diseases especially rinderpest (almost wiped the species in 1890's) and goitre (Kingdon, 1997; Bosley, 2010). Predation by lions, hyena, leopard and python is another reason for the population decline. Deforestation of the mountain forest and climate change has led to loss of the prime habitats of mountain bongo.

Some intervention measures have been put in place to reverse the population decline and conserve the species. They include establishing populations in zoos where breeding is done as well as study the species whose ecological information is scanty, re-introduction of mountain bongo from zoos to their wild habitats (Repatriation programme of Mt. Kenya), development of intensive monitoring and implementation programmes (e.g. Bongo Surveillance Programme (BSP)) and development of a national mountain bongo strategy (Estes *et al.,* 2008; CBSG, 2010; Bosley, 2010; BSP, 2010 & 2011; Estes et al., 2010 & 2011).

2.5. Mountain bongo ecology

Information on the ecology of mountain bongo is scanty due to the habitat conditions and its elusive behavior which make observation difficult (Klaus-Hugi *et al.,* 2000; Estes *et al.,* 2008; CBSG, 2010). Available data on bongos come from poachers, captive breeding, occasional observations of bongos in their natural habitats and from one long-term study of free-ranging bongos (Kingdon, 1982; Klaus-Hugi *et al.*, 2000; CBSG, 2010; Wright *et al.,* 2011). Recently, a wealth of data of mountain bongo is available but restricted to Aberdare, Eburu and Mount Kenya where organized surveillance programmes have been established (Klaus *et al.,* 1998; Prettejohn, 2008; CBSG, 2010; BSP 2010 & 2011).

Mountain bongos are found in mountain and bamboo forests that range in altitude from 2100 to 3000 meters above sea level (Ralls, 1978; Bosley, 2010; Estes *et al.,* 2011). They also prefer precariously steep ravines that gushing rivers have gouged into the dark, wet mountainsides (Prettejohn, 2008; Estes *et al.,* 2011). The bamboo forest provides shelter but most of the feeding is in primary forest (Ralls, 1978; Kingdon, 1982; Estes *et al.,* 2008). During the dry seasons, mountain bongos may be found at lower altitudes with bamboo forest (Ralls, 1978). However, they favour disturbed areas that have fresh, low level green vegetation that might have been triggered after heavy browsing by elephants, fires, tree felling (natural or logging), fallowing or mass bamboo die offs (Kingdon, 1982; Estes *et al*., 2008).

Mountain bongo is a mixed feeder but it is believed to be more of a browser (Klaus-Hugi *et al.,* 2000). Grass may form most of the diet in forest/savanna habitats (Klaus-Hugi *et al.*, 2000) and also in forest glades (Estes *et al.,* 2008; CBSG, 2010; BSP, 2010 & 2011). The plant materials include stinging nettles, *Arundinalia alpina* (bamboo leaves), bark of trees and sapling roots dug using its horns, charred wood, dead bark, burnt wood, *Parothetus communis, Senecio bieffrae, Mimulopsis solmsii* which is characterized by periodic toxicity, bark of wild croton (*Macrostachyus*), dead wood, *Impatiens* sp, *Hypoestis verticillaris, Justicia striata, Crassocephalum montuosum, Patochetus communis, Senecio petitianus, S. nandensis, Basella alba, Phytolacca dodecandra* and *Erythrococca bongensis* (CBSG, 2010).

Salt licks in bongo range are regularly visited (Kingdon, 1982; Klaus *et al.,* 1998; Klaus-Hugi *et al.,* 2000). Bongo trails converge at salt licks and their home ranges must include salt licks (Klaus *et al.,* 1998; Klaus-Hugi *et al.*, 2000). Though salt licking is essential for nutrient supplementation, the high clay content of the geophagical soil may help in absorbing and combating secondary plant compounds (Klaus *et al.,* 1998; Klaus-Hugi *et al.,* 2000). Water is a necessity requirement of this species which explains why they live close to permanent water points (Kingdon, 1982). Due to their large bodies and habitation of densely forested areas, they require an ample supply of food which is abundant all year round with accessible under-storey leaves and shoots (Prettejohn, 2008; Estes *et al*., 2008).

This lack of mountain bongo ecology information, together with a missing updated estimate of the geographical distribution, makes the development of appropriate conservation strategies extremely difficult (Evangelista *et al.,* 2012). While a strategy for management and conservation of all mountain bongo subpopulations in Kenya has been developed (CBSG, 2010), little or none has been known or done for subpopulations that their population status is unknown for example Cherangani hills subpopulation. The strategy proposes that a population of at least 20 individuals need to be established in Cherangani hills by 2060 (CBSG, 2010).

2.6. Local community Knowledge

Inadequate information and updated estimates of geographical distribution of a critically endangered wildlife like mountain bongo can make development of appropriate conservation and management strategies, put it extremely difficult (Salvatori *et al.*, 2006). Urgent studies are required to provide information that give insights on the geographical distribution of the species and impacts the species has on the local culture and economy and vice versa (Elkan, 1996; Salvatori *et al.*, 2006; Gandiwa, 2012). This will pave way for development of strategic plans that are in line with biodiversity conservation.

Species presence data collection through intensive field surveys can be expensive and time consuming but provide wealthy information on species presence (direct sightings and tracks, diet analysis) (Elkan, 1996; Salvatori *et al.*, 2006; Gandiwa, 2012). The use of the indigenous knowledge can provide relatively easy and inexpensive information if is done in the right way. Some studies have shown that local interviews provide great insights on filling the knowledge gaps (Elkan, 1996; Salvatori *et al.,* 2006; Gandiwa, 2012).

2.7. Camera trapping

Remote camera trapping has been known to be used to survey population status of wildlife especially those that are cryptic and elusive (McCarthy *et al.,* 2010; Gil-Sánchez *et al.*, 2011; Ancrenaz *et al.*, 2012; Abi-Said and Amr, 2012). It is an easy method to undertake for a baseline data collection for such species (Abi-Said and Amr, 2012). The survey may be on areas of wildlife ecology, inventory, population dynamics, species richness, population density, habitat use, activity pattern, behavioural ecology and even studies on animal damage (Abi-Said and Amr, 2012). This method of study is non-invasive, cost effective, labour efficient and rigourous (Roberts, 2011; Gil-Sánchez *et al.*, 2011; Ancrenaz *et al.,* 2012). This means the method does not interrupts the species day to day behavior, saves on expenses of being in the field on daily basis and lastly can allow coverage of a large area with little resources and time. However, if badly used, camera trapping cannot give reliable information regarding the species or area of interest (Ancrenaz *et al.,* 2012). Therefore, careful consideration should be taken especially in camera trapping planning, questions to be well defined and the resources available (Ancrenaz *et al.*, 2012).

Cameras can be placed at sites determined by the researcher's objective, permittivity of the geographical and vegetation parameters and resources available for the study area (Rovero and Marshall, 2009). This placement can be random or systematic (Rovero *et al.*, 2005; KWS, 2010; McCarthy *et al.*, 2010; Ancrenaz *et al.*, 2012). However, a grid system of 1 or 2 kilometer apart has been proposed as it reduces biasness (Rovero and Marshall, 2009; KWS, 2010).

2.8. Reconnaissance Walks

Knowing species population size and densities is critical to understanding the species status and demography. It is also important in its conservation and management (Varman and Sukumar, 1995; Eguchi and Gerrodette, 2009; Roberts, 2011). However, many methods have been developed for species that are rare or are in an area where its visibility is poor (Varman and Sukumar, 1995; Roberts, 2011). In addition, a practical difficulty exists in carrying out random sampling in geographically remote areas (Varman and Sukumar, 1995; Roberts, 2011). As a result, direct and indirect methods have been used to estimate the species population size and densities (Varman and Sukumar, 1995; Eguchi and Gerrodette, 2009; Roberts, 2011). Direct methods use sightings while indirect methods use animal signs that were left behind by the intended species. Animal signs can be inform of footprints, droppings, browsing/grazing, prey leftovers, fur/hair, wallowing, bark stripping, resting places (Varman and Sukumar, 1995; Klaus Hugi *et al.,* 2000; Eguchi and Gerrodette, 2009; Roberts, 2011). The direct or indirect methods are aided by use of either line transects; reconnaissance or directional walks (Varman and Sukumar, 1995; Klaus *et al.,* 2000; Eguchi and Gerrodette, 2009, Rovero and Marshall, 2009; Roberts, 2011; WWF-TPO, 2011).

Reconnaissance walks involves following a line of least resistance through the survey area by following easy paths along old trails, ridge-tops, water bodies, or through areas with cleared understory which allows avoidance of steep areas and dense vegetation (WWF-TPO, 2011; Ancrenaz *et al.,* 2012). This method has been known to be efficient and cheap compared to line transect (Ancrenaz *et al.*, 2012). Reconnaissance walks provide information on spatial distribution and evaluate abundance of species of interest (Ancrenaz *et al.*, 2012). It also allows in collection of information on habitat types, degradation and human activities which may be relevant to the study (WWF-TPO, 2011; Ancrenaz *et al.*, 2012). Reconnaissance walks are easily conducted and allow for large coverage of distance per day, though it provides qualitative (or semi quantitative at best) indices only (WWF-TPO, 2011; Ancrenaz *et al.*, 2012).

CHAPTER THREE

MATERIALS AND METHODS

3.1. Study area

3.1.1. Location

The study was conducted in Cherangani hills covering an area of 3233 km^2 (Figure 3.1). However, not all of this area is covered by forest but stretches or touches on the sub-locations there in. Cherangani hills, located on the western ridge of the Great Rift Valley forms the higher water catchment for Rivers Nzoia, Turkwel and Kerio (GoK, 2007). The central coordinate of the hills is 35^o 26.00' E and 1^o 16.00' N. The hills are ancient fault-block formation of non volcanic origin which is a series of undulating upland plateau on the western side of Kenya's Great Rift Valley (GoK, 2007; Birdlife International, 2012). To the east is Elgeyo escarpment and Mt. Elgon to the west. Marich pass forms the northern boundary and Uasin Gishu county boundary demarcates the southern limit. The hills altitude rise from 2000 to 3373 meters above sea level with the highest peak of the hills being Cheptoket in the north-central section (GoK, 2007; Birdlife International, 2012).

3.1.2. Geology and soils

The hills are composed of metamorphic rocks, with conspicuous quartzite ridges and occasional veins of marble while the soils are well drained and moderately fertile (Birdlife International, 2012). In some areas, the soil consists of fertile dark brown loams which are suitable for tea farming (Encyclopaedia Britannica, 2010a). Some areas have loose soils which are lost during rainy season as landslides and soil erosion (Encyclopaedia Britannica, 2010a; Gunlycke and Anja Tuomaala, 2011).

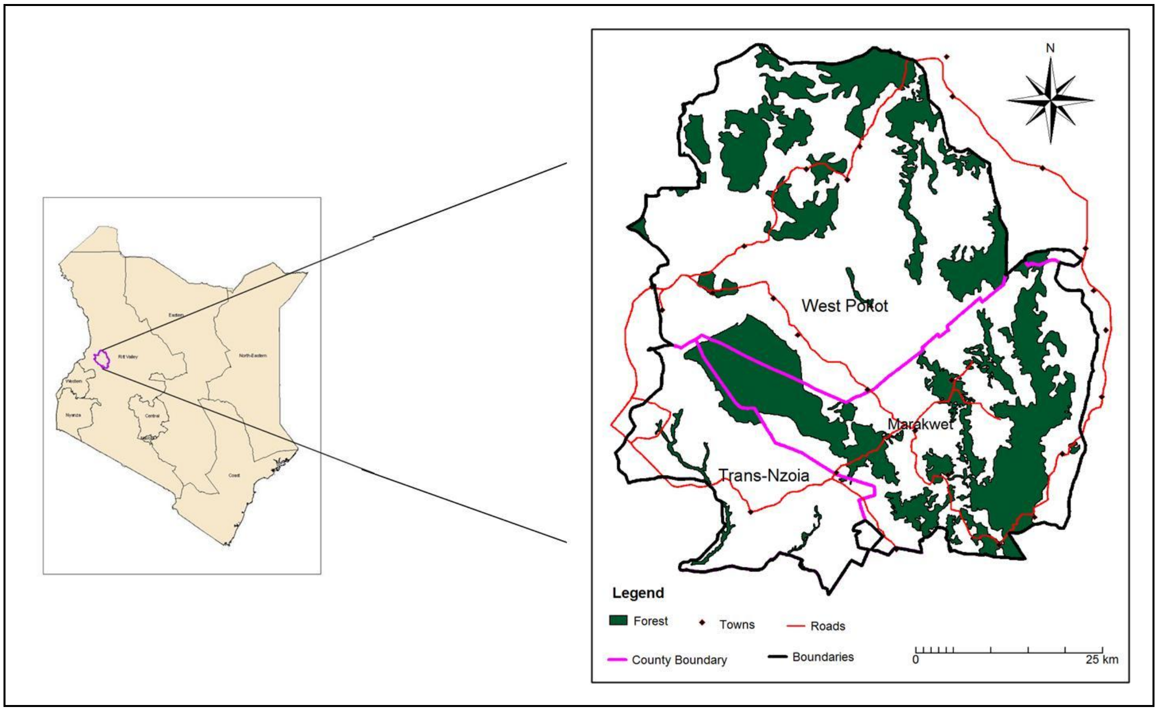

Figure 3.1: Map of the study area (Source: Author, 2012)

3.1.3. Climate

The annual rainfall varies from 1200 mm in the east to at least 1,500 mm in the wetter west (Gunlycke and Anja Tuomaala, 2011; Birdlife International, 2012). Most of the hills receive heavy rains between March and August with light showers in October through December while the other months remain dry and warm (Ministry of Tourism, 2010; Gunlycke and Anja Tuomaala, 2011). The area has an average temperature range of 8-24^0 C, but nights can be very cold especially in the peaks of Kipkunurr, Cheptoket, Kapsait and Kipteberr.

3.1.4. Administration and Economic practices

The hills are largely covered by a series of forest reserves which are made up of thirteen administrative blocks, totaling 95,600 ha of gazetted forest (Williams, 2007; Birdlife International, 2012). Of this some 60,500 ha is closed-canopy forest while the remaining being formations of bamboo, scrub, rock, grassland, moorland or heath, with about 4,000 ha of cultivation and plantation (Birdlife International, 2012). Kapkanyar, Kapolet and Kipteber Forest reserves together form a large western block of forest totaling about 20,000 ha while in the east, the Forest Reserve of Lelan, Embobut, Kerrer, Koisungor, Torapket, Chemurkoi, Kipkunur, Cheboit, Sogotio and Kapchemutwa are less well connected (Birdlife International, 2012). Apart from a large south-eastern bloc along the escarpment crest, the forest here is fragmented and separated by extensive natural grasslands, scrub and farmland (especially in the central part) (Birdlife international, 2012).

The area is economically viable. It has good scenery for ecotourism such as undulating forested slopes, cascading rivers and open grasslands filled with wild flowers and animal life (Birdlife International, 2012; Ministry of Tourism, 2010). Small scale farming is practiced and crops include maize, potatoes, cabbage, pyrethrum, millet and sorghum, while livestock rearing include sheep (wool and meat), cattle, goat, dairy cows and chicken.

3.1.5. Flora and Fauna

The hills are home to rare De Brazza's monkey and are classified as an Important Bird Area (IBA) by Birdlife International due to its rich and diverse bird species with over 73 forest-dependent species recorded, of which five species are regionally threatened

(Birdlife international, 2012; GoK, 2007). The regionally threatened species include bearded vulture or lammergeyer (*Gypaetus barbatus),* crowned hawk-eagle (*Stephanoaetus coronatus),* red-chested owlet (*Glaucidium tephronotum),* purple-throated cuckoo shrike (*Campephaga quiscalina)* and thick-billed honeyguide (*Indicator conirostris*) (Birdlife International, 2012). Mountain bongo has been recorded in the past in Cherangani hills, but its status is unknown (Birdlife International, 2010). There are a number of primates that include the vociferous colobus and sykes monkeys. There are also numerous, shy and silent creatures like red forest duiker and leopards (Ministry of Tourism, 2010).

A myriad of butterfly species with Julia's Protea Copper *(Capys juliae)* is endemic to the Cherangani Hills while two giant groundsel taxa, *Dendrosenecio cheranganiensis* and *Dendrosenecio johnstonii battiscombei (dalei),* are endemic to Cherangani hills while two notable lobelias, *Lobelia deckenii elgonensis* and *Lobelia cheranganiensis,* are shared with Mount Elgon, as is *Alchemilla elgonensis* (Birdlife International, 2012).

There are different forests types: lower western part consists of *Aningeria-Strombosia-Drypetes* forest with a large area of mixed broad-leaved yellowwood (*Podocarpus latifolius)* forest on the higher slopes; southern slopes hold *Juniperus–Nuxia–Podocarpus falcatus* forest, with heavily disturbed sickle-leaved yellowwood *(Podocarpus falcatus)* forest on the eastern slopes; the valleys in the upper peaks area shelter sizeable remnants of *Juniperus–Maytenus undata–Rapanea–Hagenia* forest (Birdlife International, 2012). Tree ferns (*Cyathea manniana*) occur in stream valleys, and there are patches of bamboo (*Arundinaria alpane*), while in clearings, umbrella thorn (*Acacia abyssinica)* occurs among scrubby grassland with a diversity of flowering plants

(Birdlife International, 2012). At higher altitudes, the forest is interspersed with a mixture of healthy vegetation and swamps, the latter with *Lobelia aberdarica* and *Senecio johnstonii* (Birdlife International, 2012).

3.1.6. The mountain bongo

The animal is known by various names: mountain bongo (English), Ndongoro (Kikuyu), Sirogoyta (Kipsigis), Siribeyi (Marakwet) (Bosley, 2010), Psirpoi (Pokot) and Sirbei (Keiyo and Sengwer).

3.1.6.1. Population status

Mountain bongo is known to occur in mountain forest of Aberdare, Mt. Kenya, Mau, Londiani, Mt. Elgon and Eburru in Kenya (CBSG, 2010). Their population has been on decline with local extinction reported for Chebalungu subpopulation and unknown status for Mau and Cherangani hills (CBSG, 2010).

3.1.6.2. Physical characteristics

Mountain bongo has widespread spiral horns that make one complete twist from the base (Bosley, 2010; Kingdon, 1982). Females' horns are typically long, narrower and more straight than those of the male (Bosley, 2010). It is a large colorful forest antelope with large ears, bright chestnut to dark brown with vivid white-yellow markings and stripes (10-16 on each side) while the face and legs have white and black patches, with white chevrons on breast and below the eyes (Bosley, 2010) (Plate 3.1). Their body length range from 110-130 cm with males much larger than females weighing 240-405 kg compared to 210-245 kg for females (Kingdon, 1982). They have long prehensile tongue used to grasp grass and leaves (Kingdon, 1982; Estes *et al.*, 2008).

Plate 3.1: Photo of a female (left) and male (right) mountain bongo showing their sexual dimorphism (Source of photo: Bosley, 2010).

3.1.6.3. Reproduction and behavior

Bongos are gregarious and non-territorial ungulates living in small groups of 2-3 adults to an average of nine including young (Bosley, 2010) but males are solitary (Bosley, 2010; Estes *et al.,* 2008; Klaus *et al.*, 1998). Some exceptions have been observed where a group of up to forty four with all ages and sexes, sometimes with more than one adult male and a group of fifty in Southern Sudan and Aberdare respectively (Bosley, 2010; Klaus-Hugi *et al.*, 2000; Kingdon, 1982). Sexual maturity is attained at the age of 24-27 months and gestation period last for 9.5 months. Observation in zoos shows that their lifespan can be up to 19 years but data for the wild is not available (Estes *et al.*, 2008).

Mountain bongos are shy animals with acute hearing and smell which make them sensitive to disturbance (Kingdon, 1982; Estes *et al.*, 2008; Bosley, 2010). When in distress they emit a bleat with limited vocalization through snorts and grunts for males while females use mooing contact calls for the calves (Kingdon, 1982; Bosley, 2010).

3.2. Materials

3.2.1. Research materials used

Research materials used in the study are summarized in Table 3.1.

Table 3.1: Research materials used

	Items	**169/59 (path/row) Dates**	**170/59 Dates**
Land cover images	Landsat TM image 2011	01/01/2011	08/01/2011
	Landsat ETM+ image 2000	27/01/2000	06/03/2000
	Landsat TM image 1995	21/01/1995	12/01/1995
	Landsat TM image 1986	28/01/1986	08/03/1986
	Landsat MSS image 1978	182/059 – 02/02/1973	
	Landsat MSS image 1973	182/059 – 01/02/1978	
Digital Elevation Model (DEM)	Landsat DEM 2010		
Other data	Soil pH map and Soil type Map		
Equipment	Global Positioning System (GPS), Camera traps, tape measure		

3.2.2. Software

A couple of softwares were used in this research to perform various tasks (Table 3.2).

Table 3.2: Sofwares used and their tasks

Software	**Task**
Ilwis Academia (Version 3.7) (ILWIS, 2011)	Processing and analyzing satellite images, Preparation of maps, Spatial multi spectral analysis, Land cover classification
Quantum GIS (Version 1.8.0) (Lyon, 2012)	Stratified random sampling selection of ground truth data
Dnrgarmin (Version 5.04.0001) (MDNR, 2008)	Uploading and downloading GPS data
Wikimapia^{TM} (Online interface) (Wikimapia, 2012)	Navigate aerially to unreached water bodies
Statistical Package for Social Science (SPSS) (Version 11.5) (IBM, 2003)	Performing statistical analysis.
Microsoft excel (Microsoft Office 2007)	Land cover mapping accuracy assessment

3.3. Methods

To achieve the objectives, methods were divided into two, namely; those that target habitat suitability and mountain bongo population status. For habitat suitability, land cover mapping was done, then, land cover change analysis. A habitat suitability model was used to develop a habitat suitability index which was further sliced to give habitat suitability classes. Further, habitat suitability maps for various years were used to determine the habitat suitability change since 1973. On the other hand, population status for mountain bongo was carried out using three methods. These include conducting local community interviews, setting cameras in some forest blocks and last, conduct reconnaissance walks. Details on how this was done are as follows;

3.3.1. Land cover mapping

Land cover mapping was conducted between July and September 2012 which was a wet season. Land cover mapping was done using Landsat TM image for 2011 (Resolution 30m) downloaded from USGS website (USGS, 2012). The images were processed using ILWIS (version 3.7) Academic software. Two images of path/row (169/59 and 170/59) were glued together to cover the study area. The clouds and shadows were removed using an auxiliary image by closest spectral fit technique (Meng *et al.*, 2009). Pixels in band 1 that contained digital numbers more than 95 were identified as clouds while cloud shadows were identified using band 4 as those that had digital number less than 45 and ratio of (band 4/band 3) is greater than 1.3 (Meng *et al.*, 2009). A cloud free image (auxiliary image) of close time periods was used to clip the cloud and shadow pixels that were used to overlay on the clouds and shadows in the image selected for analysis.

Visual interpretation of the image was based on a 4,5,3 for TM and ETM+ or 3,2,1 for MSS band combination for red, green and blue color composites respectively where color, texture, pattern and shape were key characteristics. Eighteen (18) mapping units were selected for sampling. In each mapping unit, sampling points were picked using stratified random sampling design (Knorn *et al.*, 2009) with the assistance of the Quantum GIS software (Version 1.8.0). However, mapping units were selected considering proximity routes for ease of access. A total of 972 sample points were picked and uploaded into the Global Positioning System (GPS) using Dnrgarmin software (version 5.4.1). Land cover sampling was basically done by navigating to the targeted sampling point using the hand held GPS. When the targeted sampling point was reached, visual classification was done to classify the land cover type based on its physiognomic characteristics, presence of characteristic plant species and presence of anthropogenic features. However, this was not possible for some points with water bodies and thus wikimapia™ was used to navigate to the points aerially by first navigating to already classified points. Land use and cover types/descriptions were done based on Frimpong (2011) and Andanje (2002) with some modifications.

Classification was done following supervised classification method (Evangelista *et al.*, 2012; Atickem *et al.*, 2011; Sarma *et al.*, 2011) to classify the pixels in the image. During classification, some of the 18 mapping units were merged to 14 units and further to 11. These 11 formed the land cover types which included plantation forest, Bareground, Deforested area, Farmland, Grassland, Indigenous forest, Bushland, Scrubland, Tea Farms, Water bodies and Wooded Grassland (Table 3.3).

The satellite images used were for dry season and thus there was need to use historical maps of Wikimapia^{TM} that coincides with the same time period as images. A check was also carried out in January/Febuary 2013. All these showed negligible differences and thus classification could not have varied.

Table 3.3: Description of the Land Use and land Cover classes

Land Use and Land cover type	**Description**
Plantation forest	Densely forested areas with exotic plant species (Pinus, Cypress, and Eucalyptus).
Bareground	Lands mostly covered by soils
Bushland	Lands mostly covered by shrubs and trees less than 6m height growing closely together.
Deforested area	Densely destructed forested areas
Farmland	Lands used for cultivation of food crops.
Grassland	Lands dominated by grasses rather than shrubs or trees
Indigenous Forest	Densely forested areas with indigenous plant species
Shrubland	Lands which composes mostly of shrubs with small patches of grass, bare ground.
Tea farm	Lands under tea crop (either in private or public – Nyayo Tea Zones).
Water	Water bodies (dams)
Wooded Grassland	Lands that consists of perennial grasses and other herbs with trees and shrubs that cover less than 50% of the ground.

3.3.2. Land cover change

Land cover change was assessed using various land cover maps for 6 different years (1973, 1978, 1986, 1995, 2000 and 2011) using the satellite images for the same season

(January or February). Maps for dry season were selected since wet season images had more than 40% cloud cover. The supervised classified map of 2011 (used in land cover mapping above) was used as a baseline to classify the past years land cover units using the same visual interpretation and band combination resulting to land cover maps of subsequent years.

3.3.3. Mountain bongo habitat suitability

One of the reasons for mountain bongo decline is habitat loss (Kingdon, 1982; CBSG, 2010; BSP, 2010 & 2011). For habitat suitability, the current land cover map of 2011 was used so as to depict the recent mountain bongo habitat. Mountain bongo has certain suitability parameters that need to be met for their survival. However, the weighting of the parameters may vary. Suitability parameters identified in earlier studies were used (Ralls, 1978; Kingdon, 1982; Estes *et al.*, 2008, 2010 & 2011). These factors include altitude, vegetation type (Mature forest, secondary forest, grassland patches and bamboo forest), soils (salt licks), security (from poaching) and slope. Geographical Information systems (GIS) and Remote Sensing techniques were used to extract the maps and later used to model the suitability for mountain bongo (Figure 3.2).

Respective maps representing habitat parameters were prepared and map classes allocated scores ranging from 0 (worst) to 10 (best) (Qin and Nhyus, 2010; Mehlich, 2005) indicating suitability of data to mountain bongo based on expert knowledge on the class preference. The scores were further normalized (score divided by maximum score that can be attained) to give an index value ranging from 0 to 1 to suit Ilwis Academia software standardization criterion for completeness (Table 3.4).

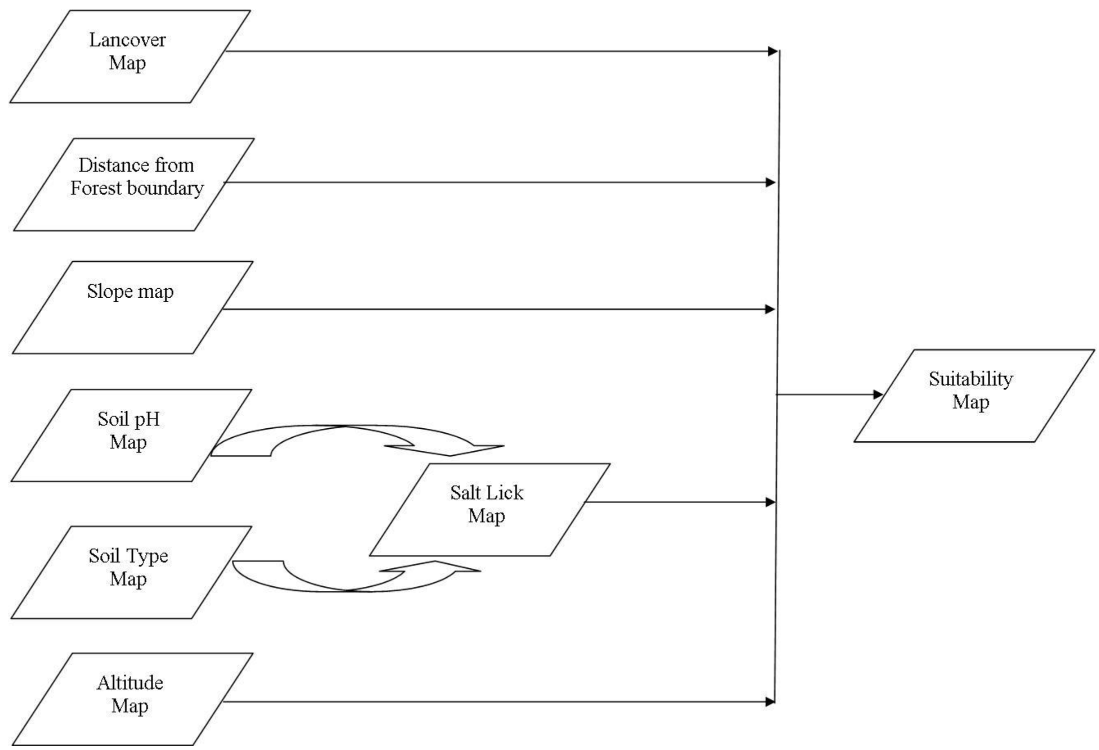

Figure 3.2: Flow chart used for developing habitat suitability model for mountain bongo

Digital Elevation Model (DEM) for Cherangani hills downloaded from USGS (USGS, 2012) was used to develop an elevation map. The altitude was sliced into ≤1600, >1600-1800, >1800-2100 and >2100 (Ralls, 1978; Kingdon, 1982; Estes *et al.*, 2008, 2010 & 2011).

Salt licks were extracted using the soil type and soil pH maps downloaded from International Livestock Research Institute (ILRI, 2010a; ILRI, 2010b). Areas that have soil texture of clay and a pH of 5-8 were extracted since combination of the two provides characteristics of salt licks (Kennedy *et al.*, 1995; Klaus et al, 1998). The soil type map was classified into Clay and non-clay while soil pH map on the other hand was prepared with three classes' namely highly acidic of pH 0-4.9, less acidic/high alkaline of pH >4.9-8.0 and less alkaline of pH >8.0-8.3 (Table 3.4). A spatial multi-criteria evaluation (SMCE) was undertaken for the clay areas and soil pH (giving them equal priority) to derive predictability index (0-1) for salt lick areas.

Table 3.4: Parameters and scores for predicting bongo habitat suitability

Habitat [Score] (Normalized value)		
Altitude (metres)	***Security (proximity to forest boundary (km))***	***Land cover***
≤ 1600 [4](0.4)		Indigenous forest [10](1.0)
>1600-1800 [7](0.7)	≤ 0 [0](0.0)	Alien forest [7](0.7)
>1800-2100 [9](0.9)	>0-3 [5](0.5)	Deforested areas [4](0.4)
>2100 [10](1.0)	>3 [10](1.0)	Grassland [4](0.4)
	Slope (degrees)	Shrubland [4](0.4)
Soil type	0-7 [4](0.4)	Bushland [4](0.4)
Clayey [10](1.0)	>7-11 [7](0.7)	Wooded Grassland [4](0.4)
Non-Clayey [0](0.0)	>11-19 [9](0.9)	Farmland [0](0.0)
Soil pH	>19-78 [10](1.0)	Bareground [0](0.0)
0-4.9 [4](0.4)		Tea Farms [0](0.0)
>4.9-8.0 [10](1.0)		
>8.0-8.3 [7](0.7)		

Mountain bongo prefers highly rugged areas (Estes *et al.*, 2011; Prettejohn, 2008). A slope map was generated from DEM map and further classified into four groups namely Flat (0-7 degrees), Gentle flat (>7-11 degrees), Semi steep (>11-19 degrees) and Steep (>19-78 degrees) (Sappi Forest, 2011).

Wildlife usually prefers areas with little or no disturbance from human activities. This means, the number of species present in an area is inversely related to human activities (Laliberte and Ripple, 2003; Estes *et al.*, 2011; Evangelista *et al.*, 2012). Based on these studies, security map was derived based on the distance from the forest boundary. Areas outside forest were termed insecure, zero to three kilometers inside forest termed safe and more than three kilometers inside the forest was rated safer.

Land cover map (Land cover map 2011) was used as the main habitat variable (Forested areas, forest glades, disturbed areas). Mountain bongo prefers areas where food plants have structural complexities which provide optimal foraging conditions (Estes *et al.*, 2011).

The habitat suitability analysis was carried out by undertaking spatial multi-criteria evaluation for the habitat parameters. Weights for the parameters were calculated using Analytical Hierarchy Process (AHP) (Saaty, 1990; Saaty, 2008; Bozoki and Rapcsak, 2008). AHP is currently being used as a strong decision making tool in weighting of habitat parameters for developing species Habitat Suitability Index (Correa-Berger, 2007; Areendran *et al.*, 2011; Carvalho *et al.*, 2012; Imam and Tesfamichael, 2013). The resultant weights for the parameters included were calculated (Table 3.5).

To undertake the habitat change, the procedure was repeated for the subsequent years where altitude, saltlicks and slope maps was the same all through but land cover and security map for that year was used.

Table 3.5: (a) Factor weighting using Analytical Hierarchy Process using Saaty Pairwise Scale and (b) Saaty's scale

(a)

	Land cover	Altitude	Security	Slope	Saltlicks	GP	Weights
Land cover	1	2	3	5	7	2.91	**0.46**
Altitude	½	1	3/2	5/2	7/2	1.46	**0.23**
Security	1/3	2/3	1	5/3	7/3	0.97	**0.15**
Slope	1/5	2/5	3/5	1	7/5	0.58	**0.09**
Saltlicks	1/7	2/7	3/7	5/7	1	0.42	**0.07**
Total						**6.34**	**1.00**

Note: GP (Geometric Progression) is calculated by product of rows and then nth root of factors.

(b)

Intensity of Importance	**Definition**
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance
9	Extreme Importance
2, 4, 6, 8	For compromises between the above

3.3.4. Questionnaires

Local community knowledge was collected by use of semi-structured questionnaires with open conversation leading to the relevant questions (Salvatori et al 2006).. The questionnaire adopted a mixed format where it used individual discussion using open- and closed- ended questions. Each questionnaire took at most 30 minutes.

The structure of the questionnaire was divided into five sections: (i) General knowledge about presence of wild animals especially carnivores and antelopes, (ii) presence of mountain bongo and possible threats, (iii) their attitude towards presence/ absence of mountain bongo, (iv) trend of the forest status and (v) personal details (Appendix 1).

A representative group of 1-7 forest users (poachers, firewood collectors, honey gatherers, livestock keepers and loggers) were picked systematically from each sub-location bordering or within the forest blocks (20 out of 33 sub-locations were targeted). The questionnaires were administered in July and ended in November 2012 where a total of 100 respondents were targeted.

At least one respondent bordering the forest block within a village was picked randomly. However, where the village covered a large stretch of the forest, two to seven respondents were picked. In this case, a start point (village boundary) touching forest block was selected and respondents were systematically picked. A respondent was picked from immediate household and the next respondent was picked after skipping 2 nearby household and so on.

Due to geographical and social barriers experienced from pre-test questionnaire conducted in Kapcherop and Kabichbich, the study area was blocked (based on tribe) and enumerators elected from each block. The qualifications of the enumerators were that (i) should have at least a secondary education, (ii) should have been a resident of the area for not less than five years and (iii) should be able to speak the local language. The enumerators were made familiar to the questions in the questionnaires before conducting the questionnaires. However, in each block, the sub locations there in were used.

First, at the start of the questionnaire, the purpose of the exercise was explained which was to understand better the relationship between people, wild animals and the forest status in the area. Maps, photos and pictures were used to ensure that the respondent and researcher were talking about the same forest and species (Doggart, 2006).

Respondent, who admitted for presence of mountain bongo in the area, was asked of sites of its locations (name of forest block). Field guides and photographs of mountain bongo were used to facilitate identification.

3.3.5. Camera trapping

This exercise was based on habitat suitability results, in that, good and optimum habitats were targeted. Cameras were deployed as from 5th October 2012 and retrieved latest 10th December 2012.

Two models of Reconyx camera trap were used namely Reconyx RM45 RapidFire and PC800 HyperFire (Reconyx Inc., WI, USA). A total of 18 cameras (14 former model and 4 later) were deployed in two forest blocks (Kipkunnur and Kapkanyar), 9 in each block based on habitat suitability index. Cameras were placed on the selected forest blocks using a grid system of 1 kilometre (Figure 3.3). Camera-trapping site selection within the grid point (10 meter radius) was done by inspecting the forest floor for animal trails and other signs and at suspected salt licks (BSP, 2010; McCarthy *et al.,* 2010; Rovero and Marshall, 2009; Estes *et al.,* 2008) or disturbed forest mosaics that provide fresh, low-level green vegetation since these are areas much preferred by mountain bongo (BSP, 2010). A data sheet was used to record all camera-trapping stations (appendix 2).

Camera settings were as follows; time of the day was set to 12 clock system and on the local time while temperatures were set to degrees centigrade. All cameras were set to "Whole Day", allowing each camera to capture photographs twenty-four hours a day. A mature tree of a diameter of more than 30 centimeters was selected where the camera was tied on. Cameras were positioned at a height of 30-50 centimeters from the ground facing away from sun east-west path to avoid sun activation on the sensor and thus poor images (KWS, 2010; Ancrenaz *et al.*, 2012).

Camera set up and recovery was done using a plain white paper bearing the camera code (eg. Kip L1, Kip R1, Kip C1, Kap L1, Kap R1, Kap C1 etc), date and time. This provided a useful double check that the camera settings were correct and was essential to demonstrate whether the camera was still functioning normally at the end of the period of operation (KWS, 2010).

Still photos were opted instead of video to save on batteries and memory stick space. The 18 Cameras were left to run continuously for 59 days (Kapkanyar) and 58 days (Kipkunur) totaling to 1053 camera days. Due to security and remoteness of the areas where the cameras were positioned, monitoring of camera-trapping (progressive number of pictures, status of batteries, technical problems, etc.) was not possible. Data recording (identification of species photographed and event scoring) were done on a data sheet (appendix 3).

Photographs from the cameras were sorted and stored for data analysis (Abi-Said and Amr, 2012). Images of the same species captured within less than 30 minutes were termed as same species and used as one photo to avoid self-dependence and inappropriateness for statistical analysis (Abi-Said and Amr, 2012).

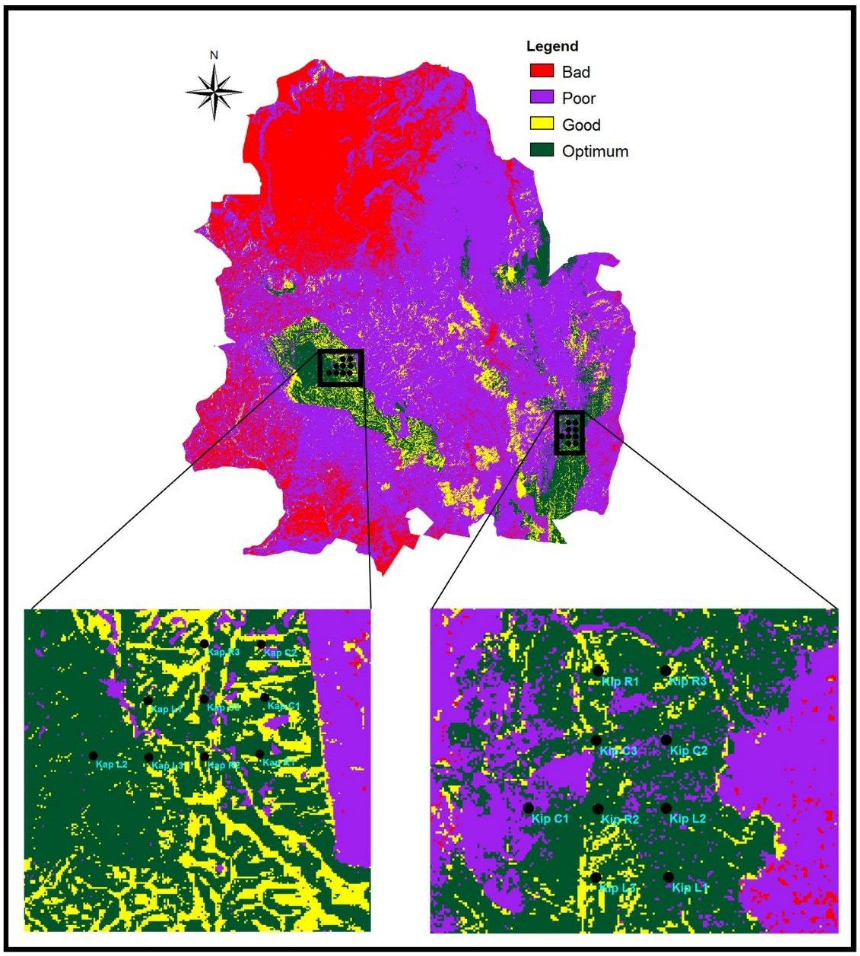

Figure 3.3: Map showing Forest blocks (Kapkanyar (Left) and Kipkunur (Right)) and camera trap sites coded) in the grid (Source: Author, 2012)

3.3.6. Reconnaissance walks

These walks were conducted between 27th April 2013 and 3rd May 2013. Transects, or "directional walks" were used to count opportunistic sighting, dung and foot prints of the mountain bongo (Varman and Sukumar, 1995; Klaus-Hugi *et al.*, 2000; Doggart, 2006). Transect walks were conducted by two people (the researcher and an assistant). Using GPS, some 3 – 4 transect walks of 2 - 3 km each (depending on vegetation density and terrain morphology) were done each day starting at around 6 or 6.30 am to 10:30 am (Doggart, 2006; WWF-TPO, 2011). Walks followed existing trails especially those that emanate from salt licks and water points. Data was recorded in notebooks and then transcribed onto a data-sheet after each transect walk (Doggart, 2006).

The start and the end time and GPS position of each walk was recorded, together with straight distance walked. An average speed of about 1 km/h within transect was walked (Doggart, 2006). For each sighting, data was recorded on the time of encounter, dung, track, number of individuals, habitat and locality notes (WWF-TPO, 2011). Behavior signs were also targeted which included bark stripping using horns, wallowing on the floor of the forest or rolling on rotten wood (Klaus-Hugi *et al.*, 2000). In addition, browsed plants were searched and assessed. Signs for other mammals were recorded during the walk but not in details.

3.3.7. Mammal checklist

Field guides were used to identify some of the animals and where vernacular names of the species were known, a translator was used to help in identifying the species. The checklist contains the order, genus and species of the animal identified and their common names (appendix 5).

3.4. Data analysis

3.4.1. Land cover mapping

A total of 292 sample points were used to assess the classification accuracy. The resultant land cover map was crossed with the 292 points and a pivot table constructed. From this, an overall, producer and user accuracies were calculated. Further omission and commission errors were calculated by subtracting producer and user accuracies from 100% each respectively.

3.4.2. Land cover change

Area of the land cover classes was calculated and used to develop a regression model that was used to predict the trend for land cover changes between 1973 and 2011. Further, ANOVA was used to check how well the model fits to the data. Significance value was set to 0.05.

3.4.3. Habitat suitability

An output map of suitability index (values range from 0-1.0) was then sliced into four habitat levels which include bad habitat (0-0.39), Poor habitat (0.40-0.69), Good habitat (0.70-0.89) and Optimal Habitat (0.90-0.10) as per Evangelista *et al.*, (2012). Area and percentages of the habitat types were calculated. The 2011 habitat suitability sliced map was crossed with the land cover map to determine which mountain bongo habitat type fall to which land cover type. Further, percentages were calculated.

Based on the estimated bongo population densities of 0.25 animals per km^2 in area known to be abundant and 0.02 animals per km^2 in other areas (East, 1999), an estimate of the probable animals that can be sustained in Cherangani hills was calculated based only on good and optimal habitat using the following formulae (Eguchi and Gerrodette, 2009).

No. of mountain bongo (N) = Population density (D) * area (A)

Using the different land cover maps and security maps, a habitat suitability change was undertaken maintaining the other habitat attributes (slope, altitude, saltlicks) constant. Area of each habitat was calculated and a linear regression and ANOVA analysis was carried out.

3.4.4. Questionnaires

The information from respondents was summarized using descriptive statistics using Statistical Package for Social Scientists (SPSS version 11.5, Chicago, USA). Open ended questions yielded to multiple responses which were coded and percentages computed.

Further, χ^2 independence analysis was carried out to check if there was a relationship between respondent details (Nearest forest, age group, gender, tribe, duration of stay, work done, education level and village) and some of the responses (sacred forest, mountain bongo meat and skin, folklore, mountain bongo population change, causes of decline, population decline mitigation and how forest and mountain bongo can benefit locals).

The associations were considered to be significant at $P< 0.05$**.** For analysis that gave out that some cells had frequency less than 5, the categories were re-coded (merged) and reanalyzed. But, in some occasions when 20% or less of the cells had frequencies more or equal to 3, the p-value was interpreted (Anthony, 2011; Tyrrell, 2009) without category merge.

3.4.5. Camera trapping

The camera trapping aimed to investigate presence of mountain bongo and other large mammals. The photos obtained were analyzed according to forest blocks, trap sites, species and trap date and time using descriptive analysis.

3.4.6. Reconnaissance walks

As Reconnaissance walks was not a systematic line-transect study, factors such as width of transect and densities of vegetation were not taken into account. Consistency in carrying out the work would accommodate for biases due to observer’s experience, ensuring that data were comparable between sites (Doggart, 2006).

CHAPTER FOUR

RESULTS

4.1. Land Cover Mapping

The supervised classification resulted in a land cover map (Figure 4.1) with an overall classification accuracy of 86.25% (Table 4.1). All the land use and land cover (LULC) units had producer accuracies of more than 65%. Bareground and shrubland had accuracies of 66.67% and 70.37% respectively, while deforested areas and plantation forest had accuracies of 74.19% and 82.12% respectively. The other classes had producer accuracies more than 85.00%.

On the other hand, water, indigenous forest and wooded grassland recorded a user accuracy of 63.64%, 66.67% and 70.00% respectively. Nonetheless, the other LULC types had user accuracy of more than 85%.

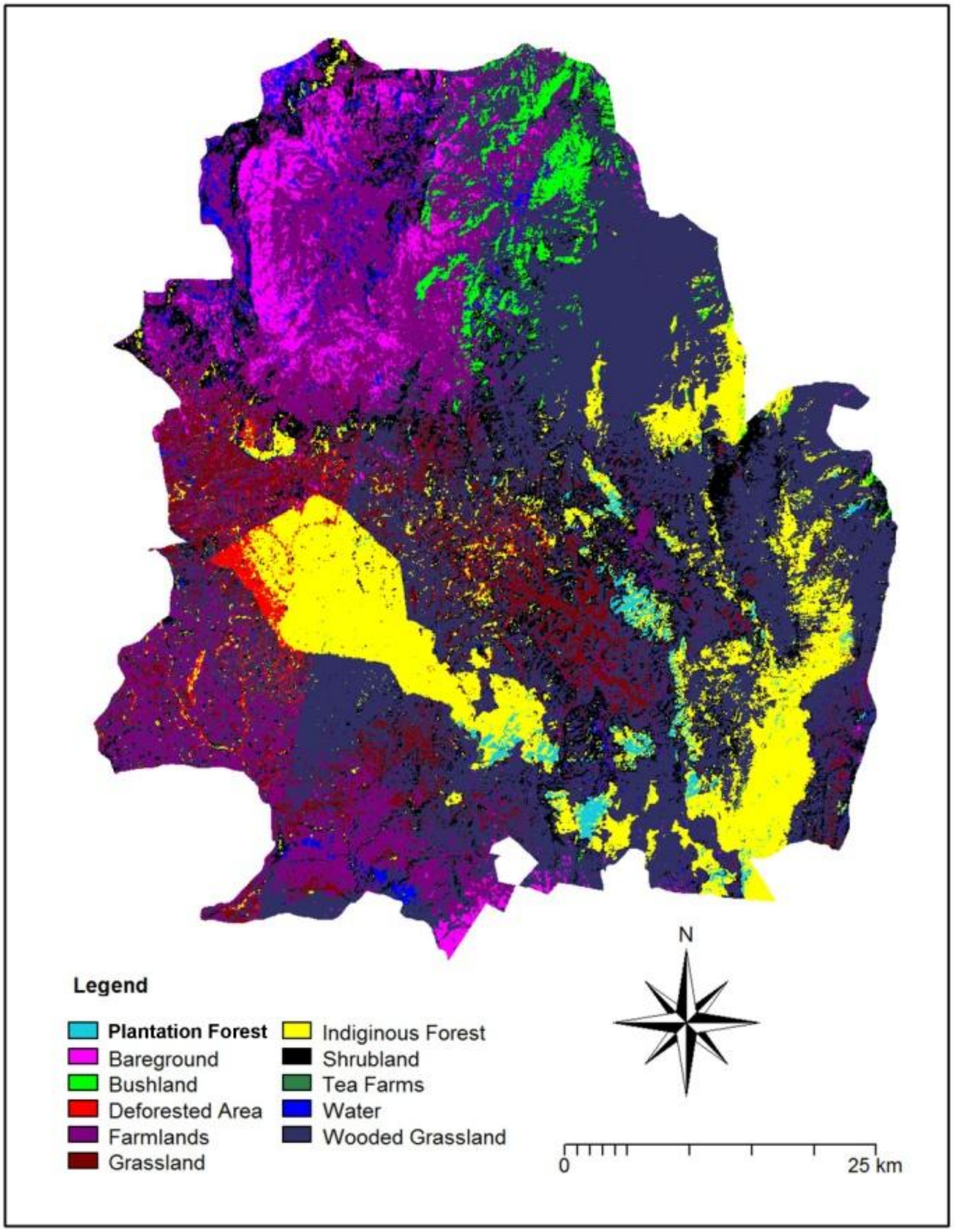

Figure 4.1: Land cover map of Cherangani hills prepared using supervised classification (Source: Author, 2013)

Table 4.1: Accuracy assessment for Cherangani hills Land Cover map 2011

	Reference Data													
Landcover Types	**Alien Forest**	**Bare-ground**	**Bush-land**	**Deforested Area**	**Farm-lands**	**Grass-land**	**Indigin-ous Forest**	**Shrub-land**	**Tea Farms**	**Water**	**Wooded Grass-land**	**Total**	**UA**	**CE**
Alien Forest	23						1	3				**27**	**85.19**	**14.81**
Bareground		18										**18**	**100.00**	**0.00**
Bushland			30									**30**	**100.00**	**0.00**
Deforested Area				23								**23**	**100.00**	**0.00**
Farmlands		3			23							**26**	**88.46**	**11.54**
Grassland		2			1	27						**30**	**90.00**	**10.00**
Indiginous Forest	5			4			28	5				**42**	**66.67**	**33.33**
Shrubland								19				**19**	**100.00**	**0.00**
Tea Farms									25			**25**	**100.00**	**0.00**
Water		3			1					7		**11**	**63.64**	**36.36**
Wooded Grassland		1			6	3			2		28	**40**	**70.00**	**30.00**
Total	**28**	**27**	**30**	**27**	**31**	**30**	**29**	**27**	**27**	**7**	**28**	**291**		
PA	**82.14**	**66.67**	**100.00**	**85.19**	**74.19**	**90.00**	**96.55**	**70.37**	**92.59**	**100.00**	**100.00**			
OE	**17.86**	**33.33**	**0.00**	**14.81**	**25.81**	**10.00**	**3.45**	**29.63**	**7.41**	**0.00**	**0.00**			
Overal Accuracy	**86.25**													

Note: UA-User Accuracy; PA- Producer Accuracy; CE- Commission Error; OE- Omission Error

4.2. Land cover change

The land cover in Cherangani hills has been experiencing variable changes (Figure 4.2). Plantation forest exhibited an insignificant increase in percentage area coverage from 0.00 (in 1973) to 1.54 (2011) (R^2= 0.05, P=0.671). Areas that are bare have not changed significantly especially on the north west of the study area which increased from 6.62% in 1973 to 15.97% in 2000 and declined to 4.09% in 2011 (R^2=0.124, P= 0.493). Bushland also exhibited similar trend (R^2= 0.035, P= 0.721) increasing from 4.15% to 10.33% and decreasing to 2.25% in 1973, 2000 and 2011, respectively. However, deforestation incidences in Cherangani hills have been on slight increase since 1986 (3.28%) to 2000 (7.40%) which was not significant (R^2= 0.387, P=0.187).

Area under farmlands have not exhibited significant increase (R^2=0.123, P=0.495) within the study area. Since 1973, farmland coverage has increased from 1.56% to 16.26% in the year 2011 though the highest recorded was in 1995 (29.15%). Grasslands on the other hand have not decreased significantly (R^2= 0.023, P=0.776) from a coverage of 12.61% in 1973 to 7.19% in 2011. Similarly, forest glades (grasslands within forest) have not increased significantly (R^2= 0.031, P=0.737) though there was a drastic decline in late 70's. Indigenous forest on the other hand has declined significantly (R^2= 0.690, P=0.041) from a coverage of 21.30% in 1973 to 12.94% in 2011.

There was no significant decrease in the shrubland (R^2= 0.606, P=0.068) from 34.67% to 10.91% in 1973 and 2011, respectively. On the other hand, Tea farms have been experiencing an increase and decrease in coverage over the 40 year period, but overall there was no significant change (R^2= 0.191, P=0.387). Water bodies coverage, increased slightly but not significantly (R^2= 0.418, P=0.165) from 0.05% in 1973 to 2.90% in 2011.

Nevertheless, this is a reflection from dams and water pans but not rivers. Wooded grassland also exhibited an increase, but not a significant change (R^2= 0.095, P=0.552) from 18.56% to 38.97% in 1973 and 2011 respectively.

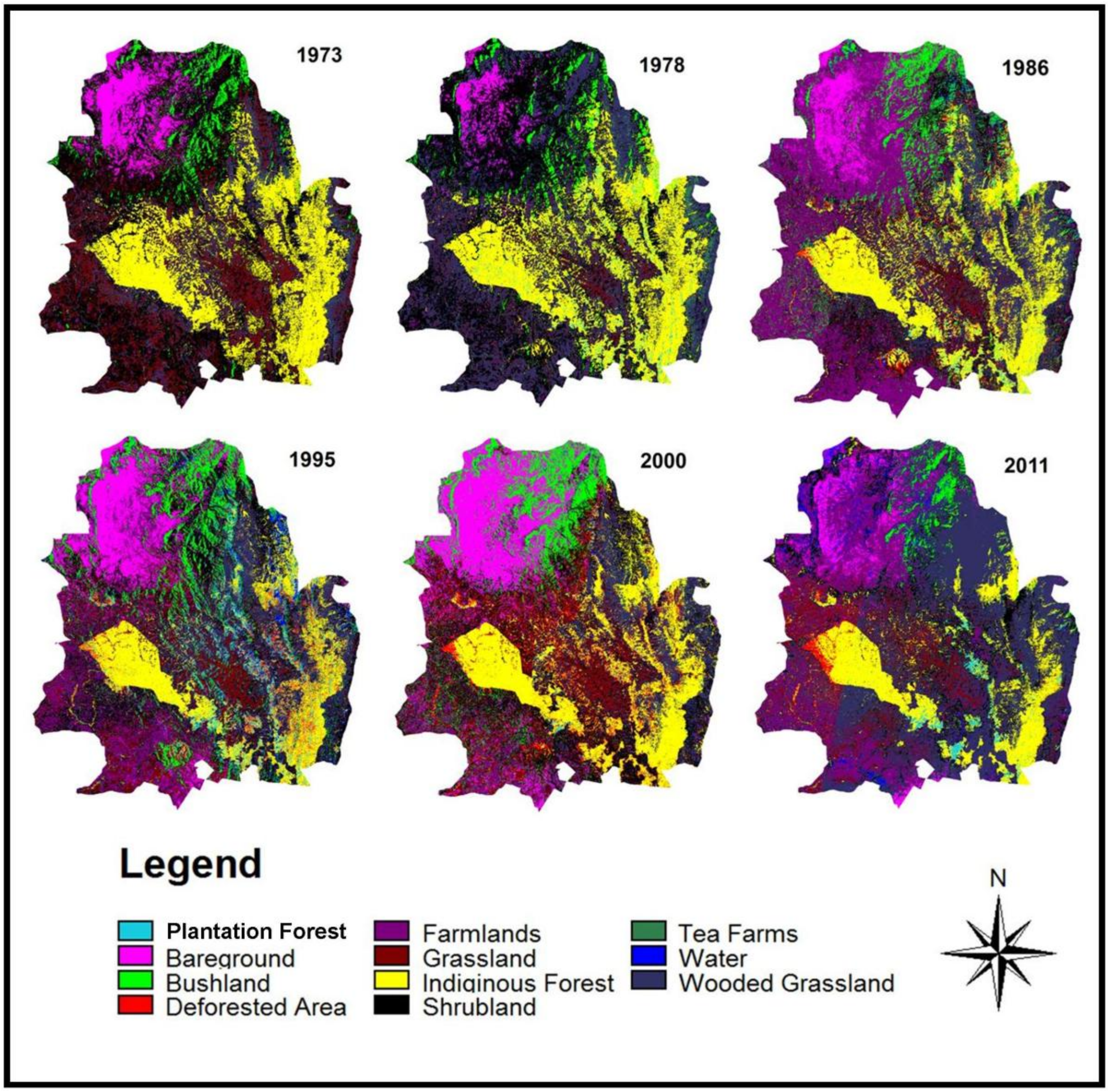

Figure 4.2: Land Cover maps for the year 1973, 1978, 1986, 1995, 2000 and 2011 for Cherangani hills (Source: Author, 2013)

4.3. Mountain bongo habitat suitability

The habitat suitability model developed for the mountain bongo (section 3.3.3) showed that Cherangani hills still has remnant habitat for the mountain Bongo (Figure 4.3). Using the threshold of the habitat quality, the results showed that bad habitat covered an area of 26.11% (844.38 km^2), poor habitat, 59.68% (1929.81 km^2), good habitat, 6.10% (197.37 km^2) and optimum habitat represented 8.10% (261.79 km^2). Based on the population estimates, the good and optimum habitat can sustain a population of up to 114 mountain bongos. However, this is made on the assumption that the two habitat types are a block not fragmented as in the current case.

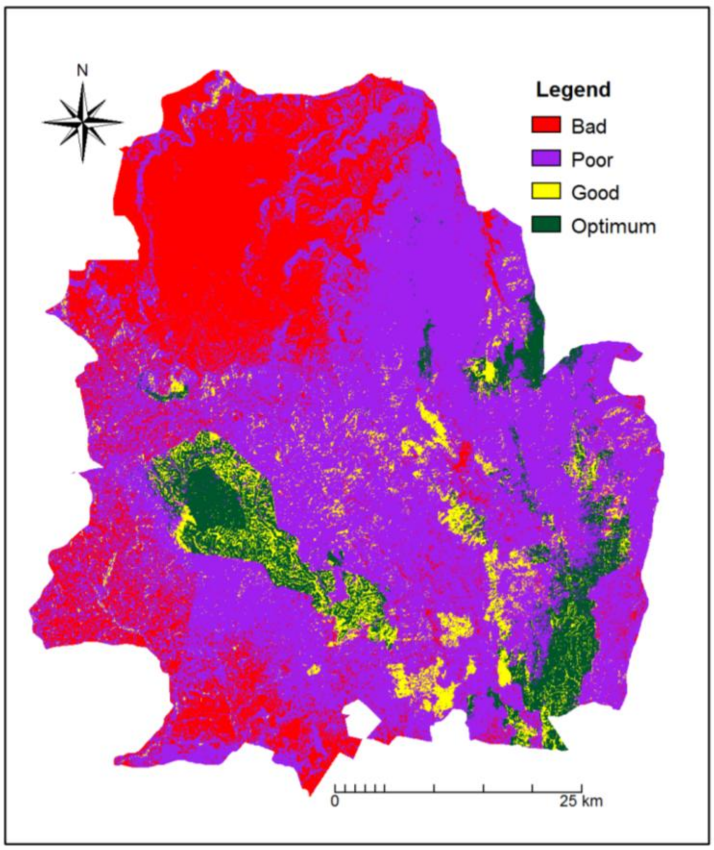

Figure 4.3: Habitat suitability map for mountain bongo in Cherangani hills (Source: Author, 2012)

Bad habitat consisted mostly of farmlands (62.88%) while poor habitat was wooded grassland (62.96%) (Table 4.2). Indigenous forest formed 80.98% of the good habitat but whole (100%) of the optimum habitat (Table 4.2).

Since indigenous forest formed most of the optimum and good habitat of mountain bongo, its significant decline translates a lot to changes to mountain bongo habitat over time in Cherangani hills (Figure 4.5). Bad habitat has been on increase though not significantly (R^2=0.288, P=0.273) from 12.94% in 1973 to 26.11% in 2011. In addition, a significant loss of good habitat was experienced (R^2=0.708, P=0.036) where the habitat covered an area of 11.96% in 1973 but only 6.52% has remained. For poor (R^2=0.07, P=0.611) and optimum (R^2=0.481, P=0.127) habitat, no significant decrease was experienced. Poor habitat has decreased from 65.62% in 1973 to 59.69% in 2011 while optimum habitat in the same time frames changed from 9.48% and 7.68% respectively.

Table 4.2: Percentage area of mountain bongo habitat covered by different land cover type

	Habitat							
Landcover	**Bad**		**Poor**		**Good**		**Optimum**	
	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
Indiginous Forest			0.60	0.03	170.68	80.98	248.25	100
Alien Forest			10.96	0.57	39.20	18.6		
Wooded Grassland	45.40	5.38	1215.25	62.96	0.17	0.08		
Farmlands	539.28	63.88	1.44	0.07				
Water	91.67	10.86	1.15	0.06				
Shrubland	21.12	2.5	331.81	17.19	0.10	0.05		
Bareground	131.39	15.56	0.12	0.01				
Bushland	4.04	0.48	68.52	3.55				
Deforested Area	0.06	0.01	62.36	3.23	0.59	0.28		
Grassland	1.43	0.17	231.38	11.99	0.03	0.01		
Tea Farms	9.87	1.17	6.49	0.34				
Total area	**844.26**	**100**	**1930.08**	**100**	**210.76**	**100**	**248.25**	**100**

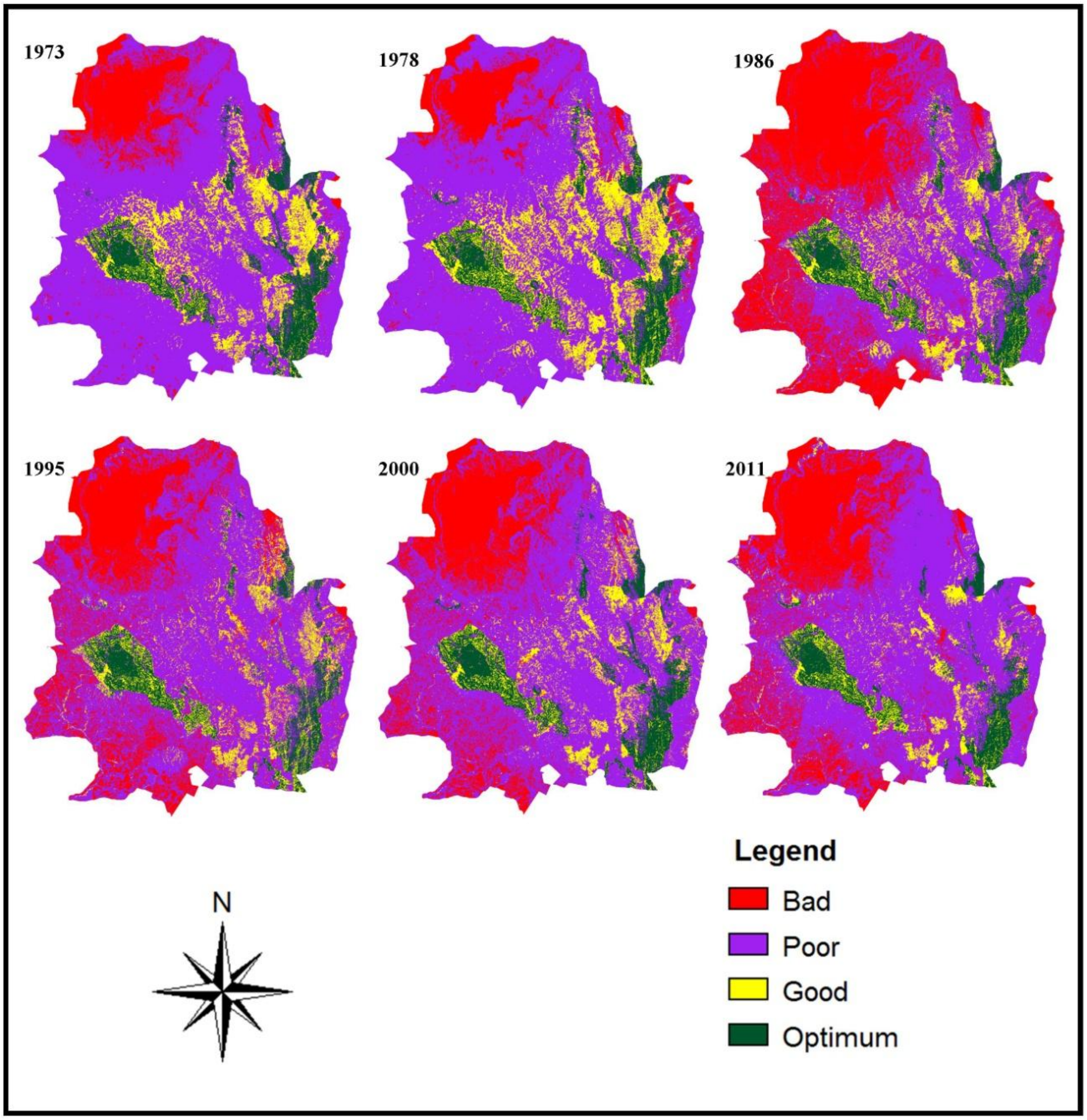

Figure 4.4: Maps showing mountain bongo habitat change from 1973 to 2011

(Source: Author, 2013)

4.4. Local community knowledge on mountain bongo and forest status

More men were interviewed (86.3%, n=83) than women (13.7%, n=12). The respondents aged 61 years and above which represented 43.2% while those aged 41-60, 21-40 and 16-20 years accounted for 31.6%, 22.1% and 3.2% respectively. The ethnic representation was more skewed; Pokot (46.3%), Sengwer (28.4%), Keiyo (10.5%), Marakwet (12.6%), Kikuyu and Kipsigis each had 1.1%. All the respondents aged 60 years and below had lived in the area since birth. However, 41.5% of those aged 61 years and above were immigrants and the remaining 58.5% had lived in Cherangani hills since birth.

Mixed farming (crop and livestock) is the major land use practice in the area (75.8%) with some of the respondents not having formal education (37.6%) (Table 4.3).

Table 4.3: Education level of the respondents

Formal education	**No. of responses**	**%**
Lower primary	16	17.2
Upper Primary	23	24.7
Secondary	15	16.1
University	3	3.2
Adult	1	1.1
None	35	37.6
Total	**93**	**100.0**

Some of the forests in Cherangani hills had sacred sites as per 54.7% of the respondents. Despite that these sacred sites were not attached to strong traditions due to varied interest (χ^2 = 58.811, df=12, P<0.001) (Table 4.4). But these responses depended on tribe (χ^2 = 19.68, df=2, P< 0.001) and duration of stay of the respondent in the area (χ^2 = 14.496, df=4, P=0.006). Sengwer community (88.89%) admitted that the forests they border had sacred sites more than the other communities. Despite this, more of the older respondents (61 years and above) from all the communities (84.0%) knew of the sacred sites than the younger respondents.

Most of the locals were aware of mountain bongo (73.7%) which varied on the respondents' closeness to forest block (χ^2 = 27.326, df=2, P<0.001), age (χ^2 = 13.954, df=2, P=0.001), tribe (χ^2 =13.726, df=2, P=0.001), duration of stay in the area (χ^2 =19.384, df=2, P<0.001) and village (χ^2 =36.433, df=5, P<0.001). Most of the respondents close to Kapolet and Kipteber forest knew mountain bongo. Most of these respondents are from Sengwer community (96.3%). In addition, respondents that were older (87.8%) and had stayed in the area for some time were aware of the mountain bongo irrespective of their ethnicity.

Table 4.4: Traditions associated with sacred sites within the forests

Traditions attached	**No. of responses**	**%**
Pray to god	7	9.9
Rain Making	5	7.0
Traditional Rituals	8	11.3
Circumcision rituals	19	26.8
Ancestral graves	4	5.6
Herbs collection	6	8.5
For grazing in dry seasons	7	9.9
Naming ceremonies	5	7.0
Traditional weddings	6	8.5
Only men allowed	1	1.4
Cleansing	1	1.4
Myth	2	2.8
Total	**74**	**100**

The locals further admitted that mountain bongo meat was eaten (66.3%). However, 61.36% of the Pokot communities (χ^2 =30.113, df=2, P<0.001) and 54.17% of the younger people (χ^2 =6.031, df=2, P=0.049) aged between 18 and 40 admitted they had not eaten mountain bongo meat. But, 96.0% of respondents who had stayed in the area for long (61 years and above) (χ^2 =16.00, df=2,P<0.001) had eaten mountain bongo meat. Further, mountain bongo meat was eaten depending on the forest blocks (χ^2 =54.909, df=2, P<0.001) and villages (χ^2 =60.362, df=5, P<0.001) where Sengwer community lived. Mountain bongo was poached specifically for subsistence (100%).

Though mountain bongo skin is beautiful, only 35.8% of the respondents used it. The skin was mainly used for making traditional bags (40.8%) and drums (20.4%) (χ^2=36.00, df=6, P<0.001) (Table 4.5). This use of mountain bongo skin depended on the forest block (χ^2=26.154, df=2, P<0.001), tribe (χ^2=7.966, df=2, P=0.019), education level (χ^2=13.350, df=4, P=0.01) and village (χ^2=47.941, df=5, P<0.001). Sengwer community (85.19%) from Kapolet and Kipteberr forest blocks (95.83%) did not use mountain bongo skin. Respondents with basic (82.35%) and without formal education (71.43%) did not use mountain bongo skin. In some occasions especially during colonial era, the mountain bongo skin was sold to whites at a negotiated price (4.2% of the respondents admitted).

Apart from skin and meat, there were other parts that were used which included horns (41.1%) for various uses (χ^2=35.077, df=8, P<0.001) and body fats (1.1%) which were used mainly to soften initiation clothes and sucking out venom from snake bites. The horn was mainly used as a communication tool (58.5%) (Table 4.6).

Table 4.5: Uses of mountain bongo skin

Use	Frequency	%
Manufacture drums	10	20.4
Traditional bags	20	40.8
Wrap pots	7	14.3
Beddings	2	4.1
Clothings	4	8.2
Initiation clothing	1	2.0
Ropes	5	10.2
Total	**49**	**100.0**

Table 4.6: Use of mountain bongo horn by the local community

Use of horn	No. of responses	%
Decoration	7	17.1
Communication	24	58.5
Controlling human birth	4	9.8
Traditional rituals	1	2.4
Store tobacco	2	4.9
Prevent witchcraft	2	4.9
Tourism attraction	1	2.4
Total	**41**	**100.0**

Mountain bongo could be trapped alive (3.2%) but was not meant for sale.

Poaching comprised of many methods (Table 4.7), where a combination of two or more methods were used at the same time. However, use of dogs (32.2%) and bow and arrow (33.3%) were preferred than other methods (χ^2= 62.253, df=6, P<0.001).

Table 4.7: Methods used in poaching mountain bongo

Method	**Responses**	**%**
Traps in salt lick	1	1.1
Use dogs	28	32.2
Arrows and Bows	29	33.3
Sharp objects	7	8.0
Fall traps	10	11.5
Snares	8	9.2
Track using their footprints	4	4.6
Total	**87**	**100**

Most of the respondents knew the local name of the mountain bongo which includes Sirbei (Keiyo, Marakwet, Sengwer) and Psirpoi (Pokot). Apart from that, the locals (52.6%) could associate mountain bongo with some folklore (Table 4.8). However, the older people knew the folklore than younger members in the society (χ^2=13.262, df=2, P=0.001). In addition, the more the duration of stay in the area, the more that person knew the folklore (χ^2=13.837, df=4, P=0.008).

Table 4.8: Folklore associated with mountain bongo in Cherangani hills

Folklore	**Frequency**	**%**
Horn used to treat lighting strike sites	1	1.7
Runs fast and jumps high across rivers	7	11.9
Not social – stay deep in forest	3	5.1
Stay away from humans	14	23.7
Not clean traditionally	12	20.3
Meat eaten by men and old women	2	3.4
Do not touch – 'Tegerio'	1	1.7
Don't talk about it in presence of children and sexually active women	12	20.3
Likes swampy places in the forest	1	1.7
When mountain bongo mix with cows it is a blessing	2	3.4
Horn and meat believed to be medicine	2	3.4
Migration of mountain bongo brings blessings	1	1.7
Sweet meat	1	1.7
Total	**59**	**100**

The respondents believed that mountain bongo was rare (61.1%) (Table 4.9) and for those who said they had seen mountain bongo (75.8%), 67.6% saw the species in 1950's to 1980's (Figure 4.5). Most respondents admitted mountain bongo population had decreased (98.6%). The responses to change was significantly dependent on tribe (χ^2= 9.701, df=2, P=0.008), age group (χ^2=6.047, df=2, P=0.049), duration of residence (χ^2=16.359, df=4,P=0.003), level of education (χ^2=10.14, df=4, P=0.038) and village where the respondent came from (χ^2=23.412, df=5, P<0.001). Pokot community (63.6%)

did not believe that mountain bongo population was on decline but the other communities did, especially the Sengwer (96.3%). It is also clear that the older the respondent (60 years and above) and the longer the duration of stay (more than 61 years), the more they admitted that the mountain bongo population had changed (85.4% and 96.0% respectively). However, most of those who had reached tertiary level of education (80.0%) were not aware of the change. But, respondents who came from villages' bordering Kapolet, Kipteber and Kipkunurr forest blocks admitted change of mountain bongo population which represented the Sengwer, Keiyo and Marakwet communities.

Table 4.9: The frequency in which the locals sighted mountain bongo in Cherangani hills

Sighting frequency	**No. of Responses**	**%**
Rare	58	61.1
Commonly	10	10.5
Not seen	25	26.3
Very rare	2	2.1
Total	**95**	**100.0**

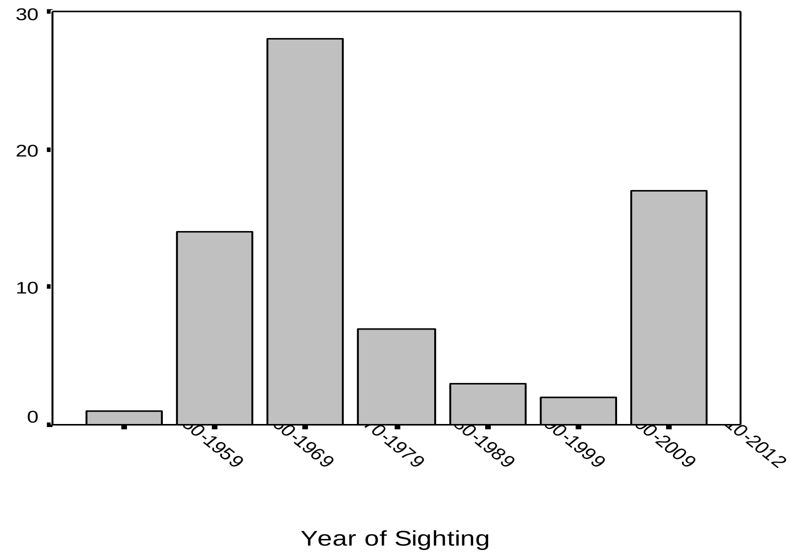

Figure 4.5: The year in which mountain bongo was seen last

The mountain bongo decline has been attributed to varied reasons (χ^2= 23.529, df=2, P<0.001) but majorly to forest destruction (52.9%) and poaching (33.3%) (Table 4.10) which depended on forest size (χ^2=40.482, df=4, P<0.001), age group (χ^2=10.488, df=4, P=0.033), tribe (χ^2=23.732, df=4, P<0.001), duration of stay (χ^2=17.941, df=4, P=0.001) and village where the respondent came from (χ^2=34.95, df=4, P<0.001). The reasons for mountain bongo decline were different depending on the forest blocks. Poaching and farming (71.4%) was the main cause for the decline in Kapolet, Kapkanyar and Kipteber forest. Forest destruction (90.6%) was responsible for mountain bongo decline in Lelan and Kipkunurr and other small forest blocks. Older respondents who had stayed in the area for more than 51 years (63.04%) knew most of the causes than those that had stayed for shorter time. On the other hand, Sengwer community (62.5%) admitted that poaching and farming caused the mountain bongo decline while Pokot communities (89.7%) blamed forest destruction.

Respondents proposed various ways to curb the alarming mountain bongo decline. These included creating awareness and protecting the species (26.4%), curb poaching (20.9%) and protect mountain bongo habitat (25.3%) (Table 4.11). Older people (67.4%) proposed more solutions to mountain bongo decline than the younger respondents (χ^2=9.244, df=2, P=0.01).

Table 4.10: Causes for mountain bongo decline in Cherangani hills

Reasons for decline	Frequency	%
Forest destruction	54	52.9
Farming	9	8.8
Poaching and gathering	34	33.3
Gives birth to only one calf	1	1.0
Climate change	3	2.9
Trans-located by government	1	1.0
Total	**102**	**100**

Table 4.11: Proposed measures to curb mountain bongo decline

Measure to conserve mountain bongo	No. of Responses	%
Create awareness and protect the animal	24	26.4
Curb poaching	19	20.9
Protect habitat	23	25.3
Fence habitat	12	13.2
Reintroduction	9	9.9
Habitat rehabilitation	2	2.2
Community to own and manage forest	2	2.2
Total	**91**	**100.0**

Most residents reported that mountain bongo did not cause conflicts (97.9%) which might be attributed to its secretive behavior (Table 4.12).

Table 4.12: The local community knowledge on mountain bongo behaviour

Bahaviour of mountain bongo	**No. of Responses**	**%**
Graze on glades	1	1.6
Sharp sense of hearing	5	7.9
Stays deep in Forest	17	27.0
Grazes with other wild animals	4	6.3
Shy	9	14.3
Follows specific routes	1	1.6
Friendly to livestock	3	4.8
Seen only in evening	13	20.6
Graze with livestock in forest	1	1.6
Jump very high and run fast	4	6.3
Male and female walked in pairs	2	3.2
Associates with buffalo	2	3.2
Aggressive to dogs	1	1.6
Total	**63**	**100.0**

The mountain bongo and forest could survive with the locals harmoniously through tourism (69.9%) (Table 4.13). Responses on benefits of mountain bongo varied with the respondents. It was significant for those near to large forest (87.5%) (χ^2=10.069, df=2, P=0.007) especially from Sengwer tribe (χ^2=11.807, df=2, P=0.003) and villages (χ^2=22.372, df=5, P<0.001). Men (63.4%) thought they could benefit more relative to women (30.8%) if benefits from mountain bongo and forest were tapped (χ^2=4.942, df=1, P=0.026).

Saltlicks are almost everywhere in the study area but those at Kimoru (11.4%), Kamoriom (11.4%), Pururu (9.1%), Chematony (6.8%) and Torapket (6.8%) were more likely to be visited by animals.

Table 4.13: Local community benefits from mountain bongo and forest

Proposed benefits	**No. of responses**	**%**
Tourism	51	69.9
Bee keeping	8	11.0
Zero Grazing	3	4.1
Controlled grazing	4	5.5
Cultural centers	3	4.1
Guard forest	3	4.1
Poverty reduction	1	1.4
Total	**73**	**100.0**

4.5. Camera trapping

A total of 1053 camera trapping days were targeted for the study. However, this could not be met since some of the cameras did not run for the total number of days either because the batteries went low (27.8%), memory stick stolen (5.6%) or camera destroyed (5.6%). Out of the nine cameras deployed in Kapkanyar forest, four cameras ran for the expected days while three had low batteries but ran for 1, 17 and 37 days respectively. For the remaining two, one was destroyed by unidentified animal (blurred images) but had run for 19 days while the other, the memory stick was stolen. On the other hand, out of nine cameras deployed in Kipkunur, eight cameras ran for the expected period while one had low battery but run for 7 days. Due to this, a total of 780 (74.1%) camera trapping days were achieved.

A total of 310 images were used in statistical analysis. Out of this, no mountain bongo images were captured. The eighteen cameras captured 9 wild mammals belonging to 6 families, human and domestic animals (cattle).

Out of the nine wild animals captured in both forest blocks, five species were captured in Kapkanyar forest except red forest duiker, dik dik, rabbit and tree hyrax (χ^2 = 57.152, df=3, P<0.001) (Figure 4.6). Among the wild animals, Bushbuck (31.3%) and Red Forest Duiker (27.4%) were the most common in the area (χ^2 = 447.317, df=8, P<0.001). Bushbuck (85.7%) was common in Kapkanyar forest block (χ^2 = 132.531, df=4, P<0.001), but, in Kipkunur, red forest duicker (44.7%) was common (χ^2 = 359.189, df=8, P<0.001). More captures of bushbuck were made in areas deep in the forest (Kap L2 and Kip C1) (Appendix 4).

Cattle were only recorded in one site in Kapkanyar on two occasions while three sites captured cattle on nineteen occasions in Kipkunur forest block. No human activities were captured in Kapkanyar but 2 sites captured people with “Pangas” (Plate 4.1) in Kipkunur.

Animals that were captured utilized the sites at different times (χ2 = 153.401, df= 2, P< 0.001). Six of the species were mostly captured during day time (diurnal) (66.8%) with total capture of wild pig, human, monkey and tree hyrax. Rat was only captured at night (nocturnal) (18.1%) while rabbit were captured at dawn and dusk (crepuscular) (15.1%).

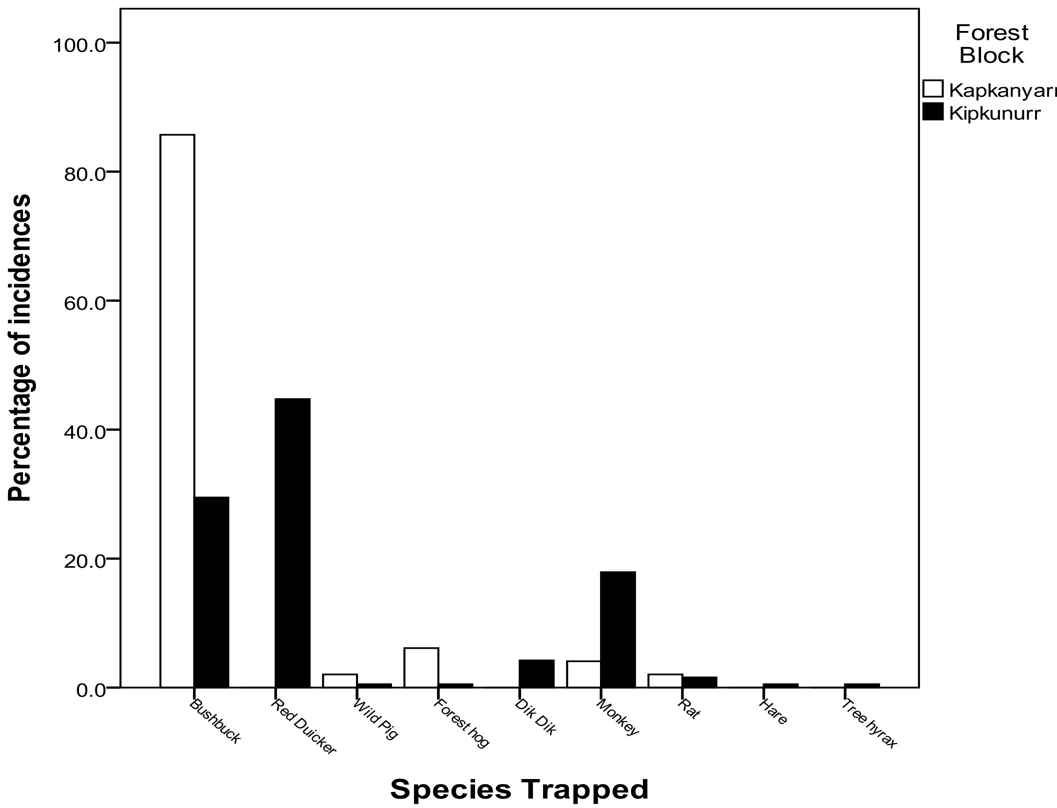

Figure 4.6: Animal species captured in the Kapkanyar and Kipkunur forest blocks

Plate 4.1: Two people with "pangas" (machete) captured by camera Kip L1 (Kipkunur forest block) (Source: Author, 2012)

4.6. Reconnaissance walks

A total of 17.62 km of reconnaissance walks was done in Kapolet (4.71 km) and Kipkunnur (13.91 km) forest (Figure 4.7). No mountain bongo signs were encountered in the sampled sites. Signs of other mammals and human activities were recorded which did not vary significantly between the forest blocks (χ^2 = 2.079, df=2, P=0.364) (Figure 4.8). Nevertheless, two out of three forest antelopes (bushbuck and red forest duicker) were encountered in the two blocks but dik dik was only present in Kipkunnur Forest.

Human visitation were evident in the areas sampled with no significant variation (χ^2 = 1.667, df=1, P=0.197). However, charcoal production (33.3%) and wildlife trapping (fall traps and snares) (13.3%) were only encountered in Kapolet forest.

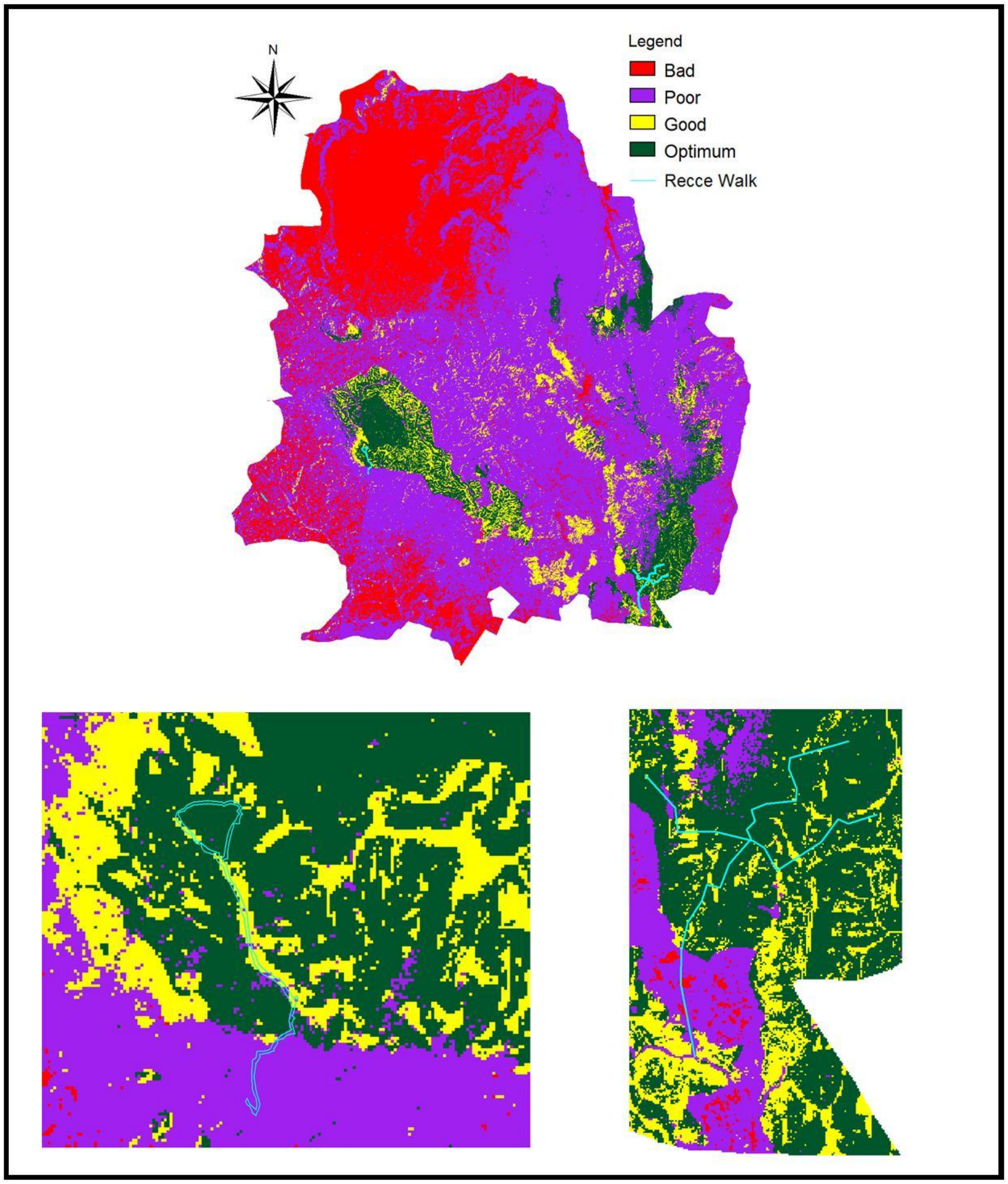

Figure 4.7: Map of selected forest blocks and Transect walks (Source: Author, 2013)

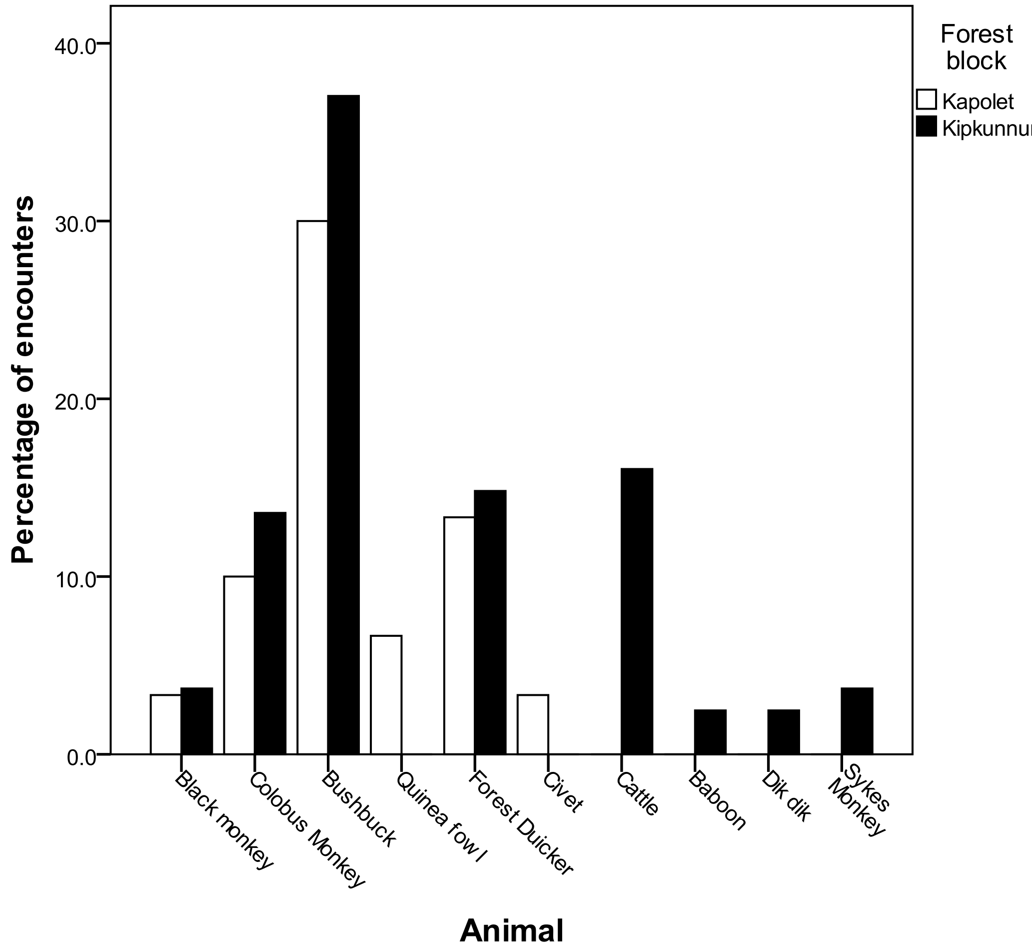

Figure 4.8: Animal encounter in Kapolet and Kipkunur forest blocks

CHAPTER FIVE

DISCUSSION

5.1. Land cover change

Cherangani hills have been facing threats from human activities and climatic variations which have impacted on land cover. Indigenous forest in the study area has experienced significant decrease. However, conclusions from a short term land cover change study might be misleading. For example, study carried out by UNEP and DRSRS showed no significant change in forest cover of Cherangani hills between 2000 and 2003 (GoK, 2007) which is similar to the results of this study that shows no significant change between 1995 and 2011. However, the significant decrease in the area covered by indigenous forest concurs with the study by Gunlycke and Tuomaala (2011).

Human population increase in Cherangani hills was as a result from either population growth or immigration (Gunlycke and Tuomaala, 2011). This has led to increased pressure on the limited resources especially on building and fencing materials. The East African pencil Cedar (*Juniperus procera*) for example has been cut for building material (post and timber) and fencing material (posts or also making wooden fence).

Indigenous forest on private and public lands were destroyed especially in 1970’s and 1980’s in areas near or within Kapkanyar and Embobut forest blocks. After gazettement of the forest blocks in 1964 (Williams, 2007), the locals destroyed forest on their land which left the gazetted forest isolated. However, little land cover change was observed for the gazetted forests which are under the management of Kenya Forest Service (KFS).

Despite this, legal logging occurs within gazetted forests but is done selectively which does not account for change.

The non-significant change of the indigenous forest between 1995 and 2011 translates to a stable mountain bongo habitat. If only the illegal encroachments to the forest can be contained, this mountain bongo habitat can be sustained for a long time. However, if no stern and effective management actions are put in place, despite the reduced rate of deforestation, a large percentage of the forest would be wiped out by 2100 (Gunlycke and Tuomaala, 2011).

Fluctuation in land cover under plantation forest in Cherangani hills can be attributed to agro-forestry and harvesting. Due to the recent advocacy of planting trees on private lands especially in Trans Nzoia, a slight increase in the area under plantation forest has been detected (Mathu, 2011). In addition to this, some government lands under indigenous forest were converted into pines and cypress plantations near Nyayo tea zones. However, when the trees mature, they are harvested and thus fluctuations of the land cover under plantation forest.

Grazing is one of the illegal human encroachments to the forest. Forest glades have been converted to individual family 'bomas' that host livestock that graze in the forest. In addition, temporary structures to shelter herders have been established in some of the glades where fire has been used in cooking and keeping warm while in the forest. Charcoal production has been evident in some of the areas close to these glades. Unfortunately, fires have gone sometimes wild beyond control and destroyed part of the forest. This has not been extensive like those of Mt. Kenya and Aberdare fires (Muchiri and Munyeki, 2012; Njagi, 2012). The destroyed areas have led to open areas that have been converted to grassland.

Pokot community lives in the North-west, North and North eastern part of the study area (Davis, 2006). Pokot are pastoralists and they value livestock much, especially cattle. Land is communally owned and thus livestock carrying capacity is not considered for sustainability of the land resources which are challenged by the climatic conditions and poor soils. The large number of livestock has led to degradation that has left some of the lands bare. Drought that hit the area in 1984 (Mateche, 2011) and human population growth have contributed to loss of vegetation in some areas.

The hilly peaks in the study area have experienced little interference by human activities due to its steepness and rockiness. They receive quite a substantial amount of rain and thus little change has been experienced in these areas. However due to poor soils, bush-lands have been supported by the hill sides more particularly in the north east part of the study area (the highest hills are found here).

Marakwets’ and Keiyos’ are mixed farmers on small scale and they occupy the eastern and south eastern part of the study area where crop growing (maize, potatoes, beans, cabbages, kales) for subsistence and in case of large harvests are sold for basic needs. Livestock (cattle, sheep and goats) are reared in family owned lands in small numbers. These farming systems have not significantly changed over time. The western and south western of Cherangani hills is Trans Nzoia County, where large scale farming of maize and wheat has been practiced since colonial era. Most of the area capable for mechanized agriculture has already been utilized.

Kapolet forest block in Trans Nzoia County has been encroached by the Sengwer community leading to high deforestation. But, the current involvement of stakeholders in natural resource conservation has led to reductions in deforestation incidences. Tea farms have contributed to deforestation especially in Nyayo Tea Zone (Kapcherop) during establishments. Some farms are owned privately especially in Trans Nzoia and Kapcherop in which the size of the land depends on the returns from the crop.

Water is not scarce in most of the area apart from the arid lands which are not suitable for mountain bongo survival. Most of the rivers flow all year round and almost all originate from the hill slopes. In addition, there are many natural springs in the forested areas.

5.2. Habitat suitability for mountain bongo

Cherangani hills have forested areas that are suitable for mountain bongo survival despite the passive management. The forest blocks are managed by Kenya Forest Service (KFS) but human encroachment is evident. The optimal habitat provides 90-100% of mountain bongo requirements, which shows that there is assurance that the animal will survive in those areas. If security can be beefed up in the forested areas, then we will be able to increase the suitability of the good habitat. This means the good habitat which occurs in non ravine areas can still be utilized by mountain bongo and later return to the nearby ravines.

In Cherangani hills, areas covered by forests either provide a good or optimum habitat for the mountain bongo. The good habitat in forested areas shows that it provides all habitat requirements but because of its slope, its suitability has been reduced from optimum to good. Land cover and security might therefore be the major driving force for mountain bongo decline since slope, altitude and saltlicks rarely change. As clearly indicated by the results, there is some intact mountain bongo habitat in Cherangani hills though fragmented.

The forests in Cherangani hills have suffered loss based on the vegetation change analysis and thus direct relation to habitat loss for the mountain bongo. In addition, the habitat is fragmented and sandwiched by human habitation which makes linkages impossible. The habitat loss and poaching was blamed for decline of mountain bongo in late 1960s (Price, 1969).

Poaching by the locals and the immigrants has been reported to be the main cause of decline of the species in the past (Price, 1969). Sengwer and Luhya community have been encroaching on Kapolet, Kipteberr and Kapkanyar forest blocks where they depend on the forest directly for meat, honey, timber, poles and other building materials. Despite the belief by the Sengwer that mountain bongo is a cursed animal (should not be touched); they still poach it for meat. This is contradictory since they admit that the mountain bongo population has declined and are currently rarely seen due to poaching by the Luhyas. Pokot community on the other hand blames the Sengwer community for decline of the mountain bongo. In fact some of the Pokot admitted that mountain bongo population had increased on the forest blocks on their side since they are not poachers.

Pokot on the other hand are herders and encroach into the forest in search of pasture. Large herds of cattle were found inside the forest owned by Pokot and Marakwet communities. Pokot believe that mountain bongo behaviour of grazing with their cattle herds in some occasions was a blessing and thus had a positive attitude towards the species. This makes them attribute an increase of the species to the good relations among cattle, mountain bongo and Pokot.

Apart from poaching and habitat loss, breeding of mountain bongo might have been interfered with in Cherangani hills in 1960's (Price, 1969). Price (1969) reported that due to deforestation along some areas, typical family herds broke up and no spoor of more than one animal was seen as well as for young ones. Further, the author (Price) admitted the destruction of the social structure might have brought breeding to an end and local extinction could occur.

5.3. Local community knowledge

Immigration has been experienced in Cherangani hills as earlier than 1955 especially on the rugged high altitude areas. This was so since the white settlers occupied the flat fertile areas for agriculture (Davies, 2006). This influx and population growth by the residents might have led to opening up of the forested areas for settlement and agriculture. Rampant deforestation in Cherangani hills might have led the government to gazette it in 1964 (Williams, 2007). Though, people admitted that there were sacred forests in Cherangani hills, no strong beliefs were attached to it which left the forest unprotected by the locals: no local ownership. Illegal encroachment to the forest still exists even today (Gunlycke and Tuomaala, 2011).

The source of income in the area is predominantly small-scale mixed farming which in most cases is unsustainable. Considering the level of education and income sources in the area, the locals have to supplement farming by harvesting forest products. Despite having a higher level of education, those that have white collar jobs, still keep livestock which are often grazed in the forest.

Poaching for mountain bongo meat, skin and horn was evident in the area though for subsistence which relates to the methods used and the locals admitting the species was not sold. However, poaching was done in an uncontrolled manner and incase of increased intensity, it might warrant mountain bongo population decline. Demand of horn for communication purposes was insignificant in that most people did not own it. Specific people owned one and it could be borrowed for use in some occasions. As long as the stories and beliefs associated to mountain bongo stand, the species survival could be guaranteed. But, these beliefs might not be a representation of the whole local population and thus do not change the behavior of the hunters.

The locals admitted that mountain bongo are rare and was last seen three decades ago in the area which is clear proof that the mountain bongo population was on a declining trend. However, the younger generation seems to confuse bushbuck with mountain bongo. It is due to such information that might have made some authors (CBSG, 2010; BSP, 2010, 2011) to conclude that mountain bongo went extinct in Cherangani hills in 1980's. The decline of the species could have been contributed by habitat loss through massive deforestation (Price 1969; Williams, 2007; Prettejohn, 2008). Habitat loss on the other hand might have exposed mountain bongo to predation in two ways. One, its shelter was destroyed and two, food shortage, leading to much time being spent in search of food thereby exposing it to predators (Carnivores and humans). A massive bamboo cutting is evident in some areas especially in Kipkunur forest but no bamboo was encountered in Kapkanyar forest when mounting cameras, but, locals close to the forest fenced their farms using bamboo. Areas deeper in the forest might be the only remaining safe haven for the mountain bongos.

Livestock incursions into the forests was common (Tulel *personal communication*) which have reduced the quality of the mountain bongo habitat. Most of the forest glades were occupied by cattle (night bomas). However, some areas in the forest that had mountain bongo habitat qualities were observed (food plants, bamboo cover, ravines and presence of saltlicks) (Prettejohn, 2008; BSP, 2010, 2011).

Lack of tangible and sustainable benefits from the forest and its products remain a major cause for forest destruction in Cherangani hills.

5.4. Camera trapping

Low animal captures were experienced in forest areas close to where human activities (cattle and human) were intensive. This concurs with study carried out by Laliberte and Ripple (2003) which concluded that most of the wildlife species, especially mammals, which are prone to poaching by human, prefer to occupy areas far from human activities. Areas encroached into by humans were avoided by secretive wildlife species which require pristine areas for their survival. However, those species that can tolerate and coexist with humans (e.g. bushbuck, red forest duicker and hare) were found to use human frequented areas in different times.

The low number of photos captured by cameras may be explained by the fact that, the species is either present in low densities or the selected camera sites comprised of marginal habitat (Rovero *et al*. 2005). According to Abi-Said and Amr (2012), the non-capture may mean that the species is either secretive or reflects its rarity. Some species have neither been photographed nor sighted with certainty in camera trapping studies even when they are known to occur (Rovero *et al.,* 2005). The encounter rates between individual species depends on their densities (Rovero and Marshall, 2009; Abi-Said and Amr, 2012).

Mountain bongo was not captured in the camera sites. This does not imply absence of the species in Cherangani hills (Anchrenaz et al., 2012). Such lack of detection could be attributed to a number of reasons. First, the study area might have not been sampled in totality and second, the sampling design might have missed the much preferred habitat for the species. However, sampling the whole study area in this case could have been too expensive, time consuming and beyond the available resources and thus sampling of selected forest blocks was the best option.

Mountain bongo is not territorial and thus a long term monitoring of the forest blocks could help reveal its presence or absence. Short term camera trapping have shown unrepresentative of a species home ranges (Gil-Sanchez, 2011) meaning a long term trapping should be opted. As much as camera trapping have been thought to be noninvasive (McCarthy *et al.,* 2010; Gil-Sanchez *et al.,* 2011), this might not be so for species that have acute sense of smell like mountain bongo.

5.5. Reconnaissance walks

Despite the efforts made to search for the signs of mountain bongo using experienced poachers along the trails, no fruitful results were achieved. This confirmed the warning that the species might have gone locally extinct since they had not been found during their recent poaching expeditions. Poaching activities were encountered, including active and old traps in most trails in Kapolet forest block, a situation which is worrying.

Encounters with bushbuck signs were common in both forests which mean that the species is common, despite the high poaching rate in the area. Poaching for mountain bongo is hard due to its secretive nature and ruggedness of the habitat it occupies (Estes *et al.*, 2011). This means that poaching could not have reduced its population to the point of local extinction. Regrettably, no mountain bongo signs were detected on the trails even those close to rugged areas.

Human activities were encountered in both forest blocks. Illegal grazing, charcoal production and timber and pole harvesting was evident which concurs with Birdlife International (2012). This has contributed to the forest destruction and thus has direct relation to habitat loss for mountain bongo.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

The study concludes that:

1. The indigenous forest in Cherangani hills has significantly declined between 1973 and 2011. Most of the decline was experienced on private owned lands.
2. Cherangani hills has suitable mountain bongo habitat of 197.37 km^2 (good habitat) and 261.79 km^2 (Optimum habitat).
3. The good mountain bongo habitat has significantly declined between 1973 and 2011. This is in line with the decline of the indigenous forest which forms most of the good and optimum habitat of mountain bongo.
4. A population of up to 114 mountain bongos can be sustained in Cherangani hills' good and optimum habitats.
5. There is ample knowledge of the mountain bongo by the local community especially the old members. They were aware that the mountain bongo had seriously declined or could be locally extinct in Cherangani hills and attributed this to forest destruction and poaching. They further confirmed that the forests in Cherangani hills had declined both in quality and quantity and would want to participate in its conservation.
6. No mountain bongos were found in Cherangani hills and therefore this species is deemed to be locally extinct in this area.
7. Cherangani hills hosts a number of large herbivores which include bushbuck, red forest duicker, wild pig, forest hog, dik dik and sykes monkey.

6.2. Recommendations

In order to protect the Cherangani hills forest, alternative source of income must be provided to locals to mitigate dependence on the forests. To achieve this,

1. Farmers should be helped to increase income opportunities through better farming practices and prices for farm products so that they do not rely heavily on natural products.
2. Subsistence poachers to be educated and given awareness on cheap, alternative and sustainable source of proteins either through chicken farming or fish farming.
3. For honey gatherers, commercial bee keeping for honey production would work for them. Awareness, education and training on modern ways of production and processing honey and wax, plus packaging and marketing the products should be undertaken.
4. Firewood and charcoal is the most common source of energy in the area used for cooking in schools, trading centers and households. This depends majorly on the forest. To curb this, residents should be educated to opt for green energy which include biogas, wind and solar. In addition, use of technology in production of charcoal from ‘waste’ (farm waste, prunings from trees, market waste, unpalatable grass, maize straw and cobs).
5. Conservation of the existing forest must be done. Currently, locals believe the forest is a resource for exploitation since no other tangible benefits are obtained. If the forest can be able to provide tangible benefits to the locals apart from the non tangible benefits which they belief it benefits other people in lower areas like water to far towns for example Eldoret and Kitale. Currently, eco-tourism is yet to be developed

to benefit the locals. Apart from the forest biodiversity richness and abundance, the area is rich in scenery, culture and sport (athletics training). Only proper infrastructure needs to be upgraded and services sector improved.

6. Another source of income for the locals is through carbon credits business. This needs cooperation between Kenya Forest Service and locals on development of CDM (Carbon Development Mechanism) and REDDS (Reduction of Emissions from Environmental Deforestation and Degradation) products. Returns got from the business, some of it to be shared among the locals.
7. More research should be undertaken to explore the other forest blocks for further verification on the (i) presence/absence of mountain bongo and (ii) re-introduction potential of mountain bongo in Cherangani hills in that, the threats should be identified and mitigated before re-introductions.
8. A management plan to be prepared to protect, manage and sustainably conserve the Cherangani hills water tower and biodiversity in it.

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APPENDICES

Appendix I: Questionnaire data sheet

Assistant :_______ Questionnaire code:______ Date:_________________________

Nearest forest Block:_________________Village:__________________

Respondent details

Gender:_______ Age: 16- 20 21-40 41-60 61+

Tribe:_______Duration of stay (Years):____________ Career:________________

High education attained:__________________________

1. Are there any sacred forest in this area? ________If yes. Which forest(s) ______
2. What are the traditions associated with the sacred forest? _________________
3. Are you familiar with the mountain bongo? No / Yes
4. Do people in your village eat mountain bongo meat? No / Yes
5. Is the meat sold? No / Yes
6. If yes. To whom and for how much?____________________________________
7. Do people in your village use the mountain bongo skin? No / Yes
8. If yes. Please specify____
9. Is the skin of mountain bongo sold? No / Yes
10. If yes. To whom and for how much?___________________________________
11. Apart from the meat and skin, which other parts of the animal is used by the people in your village?____
12. What for?____
13. Do people in your village trap and sell the mountain bongo alive? No / Yes

14. If yes. To whom and for how much?______________________________________

15. Describe how the animals are trapped or hunted?__________________________

16. Do you know the local name of mountain bongo? No / Yes.

List (Language)________________________(Name)______________________________

17. Do you know of any local stories about this animal? No / Yes.

Specify____

18. How frequently do you see mountain bongo?_____________________________

19. Where do you see the mountain bongo?_______ Specify the forest Block_________

20. When was the last time you saw the mountain bongo?_______________________

21. Have you noticed a change in the abundance of mountain bongo? No/Yes

22. If yes. Is it Decreasing/Increasing?

23. Over what time period?____

24. Any comment on mountain bongo abundance?_____________________________

25. Why do you think there has been a change? ______________________ _______

26. Do these animals cause any problems in your village? No/Yes

27. If yes. What kind of problems?____

28. What behaviours do the species have?_________________________________

29. What can be done to conserve the mountain bongo?_________________________

30. Is there a way in which the local people can benefit from the forest and animals without causing a decline?____

31. Which other species are seen in the forest?________on which forest block?______

32. Are there salt licks within the forest?________________. Where?___________

Any other comment?____

Appendix II: Camera trapping data sheet

Forest site:_______________ Site Number:__________ Forest Block:______

Data collector:_____________Camera type:__________ Camera No._______

UTM:____________ Nearest camera and approx. distance_____

Altitude:____________ Slope:_________ Distance to nearest Village:______

Placed (date/time):______________ Removed (date/Time):_________________________

Sampling effort (Days/Hours):__________ Placed on: Large trail: Small trail: Other___

Any signs/dungs already in site:__________________

Gross habitat:

Lowland forest		Regenerating forest	
Sub-montane forest		Riverine	
Grassland		Bamboo	
Swamp		Forest glade	

Appendix III: Data recording Sheet (a) camera recovery (b) image

(a)

Site number (Refer to Appendix 2)		Total trap hours	
Camera No. and type		Total trap days	
UTM position		Total No. of Pictures of wildlife	
Start date and time		No. of identified animals	
Stop date		No. of unidentified animals	
Stop time		No. of Unknown pictures	
Comment (broken, batteries died etc)		Data collector	

(b)

No.	Date, Time	Species	No.	Date, Time	Species

Appendix IV: Camera captures of species in specific sites and forest blocks.

Forest Block	Camera site	Bushbuck	Red forest Duicker	Cattle	Wild Pig	Forest Hog	Dik dik	Unidentified	Monkey	Rat	Human	Hare	Rock hyrax
Kapkanyar	Kap C2	0	0	0	0	0	0	1	0	0	0	0	0
	Kap C3	0	0	0	0	0	0	5	0	0	0	0	0
	Kap L1	6	0	0	0	0	0	1	0	0	0	0	0
	Kap L2	18	0	0	0	2	0	5	2	1	0	0	0
	Kap L3	8	0	0	2	1	0	1	0	0	0	0	0
	Kap R1	0	0	2	0	0	0	0	0	0	0	0	0
	Kap R2	10	0	0	0	0	0	1	0	0	0	0	0
Kipkunur	Kip C1	32	0	0	0	0	2	0	5	0	0	0	0
	Kip C2	0	15	2	0	0	1	7	2	0	1	0	0
	Kip C3	5	21	0	1	0	4	4	1	0	0	1	0
	Kip L1	6	0	11	0	0	0	2	10	0	1	0	1
	Kip L3	11	27	6	0	1	1	1	15	3	0	0	0
	Kip R1	1	1	0	0	0	0	10	0	0	0	0	0
	Kip R3	0	21	0	0	0	0	10	1	0	0	0	0

Appendix V: Provisional mammal list for Cherangani hills (source of information: Kingdon, 1982, Camera traps, Local people, Observations).

Common name	**Order**	**Scientific name**
Black and white colobus	Primate	*Colobus angolensis*
Sykes Monkey	Primate	*Cercopithecus mitis*
Striped polecat	Carnivora	*Ictonyx striatus*
Leopard	Carnivora	*Panthera pardus*
Red Forest Duicker	Artiodactyla	*Cephalophus natalensis*
De Brazza’s Monkey	Primate	*Cercopithecus neglectus*
Sitatunga	Artiodactyla	*Tragelaphus spekii*
African clawless Otter	Carnivora	*Aonyx capensis*
Common Genet	Carnivora	*Genetta genetta*
Serval	Carnivora	*Leptailurus serval*
Olive Baboon	Primate	*Papio anubis*
Guenther’s long snouted Dik dik	Artiodactyla	*Rhynchotragus guentheri*
Blue Monkey	Primate	*Cercopithecus mitis*
Wild pig	Artiodactyla	*Potamochoerus larvatus*
Warthog	Artiodactyla	*Phacochoerus africanus*
Thoma’s Bush Baby	Primate	*Galago thomasi*
Giant Forest Hog	Artiodactyla	*Hylochoerus meinertzhageni*
Porcupine	Rodentia	*Hystrix cristata*
Aardvarks	Tubulidentata	*Orycteropus afer*
Southern Bushbuck	Artiodactyla	*Tragelaphus scriptus*
Southern Tree Hyrax	Hyracoidea	*Dendrohyrax arboreus*
Rock Hyrax	Hyracoidea	*Procavia capensis*
Cape Rabbit	Lagomorpha	*Lepus capensis*
Vervet monkey	Primate	*Cercopithecus aethiops*